Visuo-spatial islets of abilities and intellectual funtioning in autism.

Shah, Amitta

VISUO-SPATIAL ISLETS OF ABILITIES AND INTELLECTUAL FUNCTIONING IN AUTISM

AMITTA SHAH, M.SC.
Institute of Psychiatry, University of London

Thesis submitted for the degree of
Doctor of Philosophy in the
University of London, Institute of Psychiatry

March 1988

ABSTRACT

The cognitive components underlying visuo-spatial islets of abilities in relation to patterns of clinical behaviours and intellectual function were investigated for two groups of autistic subjects of different IQ levels.

First, the two groups were compared on past and present clinical behaviour and psychometric test profiles. The Average IQ Autistic group whose performance IQ was in the normal range showed more severe autistic symptoms before the age of 5, earlier and better prognosis and striking islets of super-normal abilities on two visuo-spatial subtests of the Wechsler Scales, the block design and object assembly. The Lower IQ Autistic group whose Performance IQ was in the mildly retarded - borderline range showed less severe autistic behaviours before age 5, but these persisted longer. This group showed islets of normal abilities on the two subtests.

Four experiments, designed along information-processing models, were then carried out to investigate the cognitive factors which would explain these islets of visuo-spatial abilities. The performance of each autistic group was compared with either one or two control groups, stringently matched on various criteria. The findings indicated that the normal and super-normal islets of abilities of the autistic groups were achieved by one abnormal cognitive strategy (segmentation), and superior or intact functioning on other specifically spatial components of visuo-spatial tasks. Superior segmentation ability distinguished both autistic groups from control groups. However, only the Average IQ Autistic group demonstrated a superiority in the speed and accuracy of processing visuo-spatial information. These additonal advantages, together with a normal level of general intelligence, were postulated as important factors contributing to their super-normal, rather than normal, islets of visuo-spatial abilities.

The relationship between the severity of autistic behaviour before age 5, level of general intelligence, and level of performance on visuo-spatial islets was discussed with reference to each autistic group.

ACKNOWLEDGEMENTS

Many people and organizations have contributed, at various levels, to the successful completion of this thesis. In particular, I would like to express sincere thanks to the following:

- pupils and staff of the Helen Allison School and Jubilee Workshop, Gravesend; The Sybil Elgar School, Ealing; OverCliffe House, Gravesend; South East London College for further education, Lewisham; Woodmansterne School, Streatham; and Kingsdale School, Dulwich for their participation and cooperation.
- parents of all the autistic subjects for their help in the questionnaire study;
- Dr. Lorna Wing for introducing me to the complexities of autism, and providing guidance and support at all levels;
- Dr. Uta Frith for her valuable supervision throughout;
- Professor David Hand for sound advice on statistics and for introducing me to multivariate analysis;
- Mrs Barbara Alderman for her meticulous production of all the illustrations;
- Mrs Nalini Contractor for providing computing assistance and a personal pigeon service;
- Dr. Simon Baron-Cohen and Dr. Dermot Bowler for cognitive and moral support;
- The MRC Social Psychiatry Unit for material support and the use of computing facilities;
- Mrs Monica White and Ms Katheryn Ellis of the National Autistic Society for their help in finding subjects;
- The Inge Wakeman Trust for providing the colour monitor.

Finally, very special thanks are due to two people:
- Bindi for her moral support and the use of her flat to work in;
- Smit for writing the computer programmes for the mental rotation experiments, statistical assistance, and for his tolerance, encouragement and help throughout.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT)

LIST OF CONTENTS (CONT)

TABLE OF CONTENTS (CONT)

TABLE OF CONTENTS (CONT)

LIST OF TABLES

LIST OF TABLES (CONT)

LIST OF TABLES (CONT)

LIST OF FIGURES

LIST OF FIGURES (CONT)

LIST OF FIGURES (CONT)

LIST OF FIGURES (CONT)

CHAPTER ONE

INTRODUCTION

1.1. Background

Autism is a pervasive developmental disorder with the key features being severe deficits in two-way social interaction, in verbal and non-verbal communication, and a tendency to engage in repetitive stereotyped activities rather than imaginative activities.

A few descriptions of individual children with the peculiar pattern of behaviour now referred to as 'autistic' can be found in the historical literature (for example, Haslam, 1809; Itard, 1801; 1807). However, Kanner (1943) was the first person to suggest that such children suffered from a particular syndrome to which he gave the name 'early infantile autism'. Kanner's original descriptions of the classically autistic children are among the most vivid and accurate to be found in the literature. However, various modifications, in the light of research findings, have been necessary to the original diagnostic criteria proposed by Kanner. The latest of these are the criteria given in DSM III - R (APA, 1987).

One of the most puzzling and fascinating aspects of the autistic child is the dissociation between the various cognitive functions. It is a most characteristic feature of autism and is evident at all levels of intellectual ability except at the profound level of retardation where there are very few skills present to be differentiated. Most normal people perform some skills better than others, but on the whole there is high correlation between the different functions. Indeed, the fact of such a correlation is one of the most robust phenomena in psychology. By contrast, the discrepancies between abilities and deficits in the autistic child are very marked. An extreme example is the autistic person with the idiot savant type of abilities who is able to perform one skill at a level that is beyond normal competence and yet is severely or even profoundly retarded on all other skills. More commonly, the peaks of performance shown by autistic people are within the normal range but represent the only skills that are not retarded. All other skills are retarded to varying degrees. There are also autistic people, whose level of performance on the 'peaks' does not reach normal levels of functioning but is still significantly higher than the rest of the skills.

'Islets of ability' is the term commonly used to refer to these peaks of normal, near normal or superior function which occur together with marked retardation in other areas. Other less common synonyms of this term include 'special skills', 'splinter skills' and 'isolated skills'. This thesis investigates one particularly common 'islet of ability' in autistic people, namely visuo-spatial skills.

Before introducing the present study, the literature relevant to dissociation of cognitive function and the presence of islets of ability in autism is reviewed. This is only a general review in order to provide the broad context for the study. The literature most relevant to each experiment is reviewed at the beginning of each chapter.

1.2. Dissociation of function in autism - a brief history

1.2.1. Kanner's theory

In his descriptions of children with early infantile autism, Kanner gave considerable emphasis to the skills of these children. He was especially struck by the excellent rote memory of verbal and visual material shown by many of the children in his sample. Kanner did not refer to these skills as 'special' or 'isolated' but believed that they were a reflection of the underlying normal or higher intelligence of these children which could not be accessed. Kanner believed that these children could not be tested on psychometric tests. Thus, his views were based on observations and general impressions. The following quotes from his original paper (Kanner,1943) spell out his views:

> "The astounding vocabulary of the speaking children, the excellent memory for events of several years before, the phenomenal rote memory for poems and names, and the precise recollection of complex patterns and sequences bespeak good intelligence in the sense in which this word is commonly used."
> (Kanner,1943: P. 247)

His descriptions of two cases, whom he considered typical of the autistic children he had described further exemplify his views regarding the inaccessible intellectual potential of these children.

> "Jay and George, who - as events proved - were well endowed intellectually, were not capable of using their potentialities in a manner meaningful to others so long as they remained behind the barricades of their emotional isolation. It is typical of their illness, which I have named early infantile autism, that the disability to form affective ties and the resultant lack of responsiveness shut off the avenues of communication which are needed for psychometric evaluation."
> (Kanner,1952: P.702)

For about two decades after Kanner first identified and described the syndrome, it was generally accepted that autistic children were 'untestable' and that they were of normal intelligence. The main reason that this view prevailed was the observation that autistic children demonstrated certain skills that were at or above the level expected for their chronological age. Moreover, the face of an autistic child was considered 'intelligent' and they lacked the gross motor abnormalities seen in mentally retarded children. DeMyer et al. (1974) report that during those years none of these views were backed by psychometric test findings. When autistic children were presented with tasks from psychological tests, they did not respond or attempt them. Thus, intelligence tests were considered inappropriate for these children (Colbert & Koegler,1958; Gallagher,1962; Spivack & Levine, 1964). When standardized tests were used and low levels of performance were found, the results were considered invalid reflections of the children's potential (e.g. Bender & Grugett,1956).

It is thus not surprising, though remarkable, that between 1943 and 1965 there are hardly any reports regarding the intellectual abilities of autistic children in the literature. Many authors, however, had expressed a need for a reliable and valid quantification of the autistic child's level of functioning (Cassel,1957; Spivack & Levine,1964; Ward,1963; Wing,1963).

1.2.2. Psychometric Assessments

In the late 1960s and early 70s , the situation rapidly changed. Alpern (1967) reported that poor performance and 'non-cooperation' by autistic children on standardized intelligence tests was related to the difficulty of the task. He also reportd that previous attempts to test autistic children had probably failed because the tests used were not appropriate to the mental age of the child. DeMyer, Norton & Barton (1971) found that autistic children (including those of pre-school age) could be tested reliably on test items which were appropriate for their mental age rather than chronological age. There also appeared reports of intellectual abilities of older autistic children based on standardized psychometric tests (e.g. Viitamaki,1964; Wassing, 1965; Gillies, 1965; Lockyer, 1967)

These studies made it abundantly clear that the intelligence of autistic children could be measured reliably and validly and that the IQ had the same predictive power concerning eventual functioning as in any other group of children. It also became clear that Kanner's assumption that autistic children were of at least normal intelligence was not true. It is well established now that the syndrome of autism can occur at all levels of intelligence, and that the majority (between 67% and 75%) of autistic children function in the retarded range (Lotter, 1966; DeMyer, 1974; Wing & Gould, 1979). These studies also found that autistic children showed marked discrepancies between levels of development of different type of skills. Peaks and troughs of performance were common but the peaks did not always reach normal levels and were certainly not a reflection of the overall intellectual potential. These peaks were indeed only isolated abilities as aptly described by the term 'Islets of Ability'.

1.3. Islets of Abilities - Literature Review

Although it is now commonly acknowledged that islets of abilities are a characteristic feature of a large proportion of autistic children, there are no estimates of the prevalence of the different types of peaks of abilities and the different levels of the peaks in the autistic population. The only estimates that are available refer to cases where the islets of ability are shown at the extreme idiot savant level. Rimland (1978), on the basis of cases on a world register of autistic children , reported that 9.8% of the cases demonstrated some form of extreme level of islets of abilities. This study unfortunately did not look at rates of occurence of islets of abilities at other less extreme levels. O'Connor and Hermelin (1983) reported that four out of eleven idiot savant individuals identifed in hospitals for the mentally handicapped were 'clearly autistic' and 7 out of 11 showed autistic features.

The literature on islets of ability in autism is on the whole rather scanty. There are two main sources of literature. First, there are the descriptions of individual cases or small groups with particular islets of ability. Most of these describe islets of abilities in an anecdotal and qualitative manner.

1.3.1. Case Studies

The most commonly reported islet of ability in case descriptions is that of an exceptional rote memory for verbal material and visual patterns. Kanner (1943) described the occurrence of such abilities in many of his original group of autistic children. Cain (1969) described several severely retarded autistic cases with phenomenal memory for verbal material such as lengthy conversations, radio or television material, and visual memory for spatial material such as streets, routes, charts, arrangement of furniture in a home visited briefly. Goodman (1972) has described in detail a severely retarded autistic child with exceptional memory for encyclopedic type material such as names and dates of presidents, telephone numbers, area codes, magazine publishers, television programmes, producers and commercials. This ability was in marked contrast to his normal language which was limited to short phrases. Rimland (1978) found that memory and music were the most commonly reported islets of abilies in his study mentioned above. The memory skills covered a wide range of abilities including photographic memory, auditory memory for verbal, musical and written material and memory for events and incidents.

Another islet of ability described by several authors (e.g. Cain,1979; Rimland,1978) is that of mathematics and calculating calender dates. Examples of such abilities include being able to mentally multiply four digit numbers in split seconds, or calculating the square roots of numbers, or calulating the day of the week that particular dates fall on.

Drawing and art as an islet of ability does not seem to occur as frequently as memory or musical abilities, but in the few cases where it has been reported, the quality of the skill is quite extraordinary. Selfe (1977; 1983) has documented the famous case of Nadia and other autistic children who have shown exceptional drawing ability from a very early age. Selfe's analysis of these childrens' skill is discussed later. Recently, an autistic boy called Stephen has received a lot of publicity regarding his extraordinary ability to draw detailed replications of architecture which he has seen only briefly (Wiltshire,1987).

An ability to read and spell at a very early age ('hyperlexia') has been reported in several autistic children (Cobrinik,1974; Cain,1979). In all such cases, the ability to read developed precociously and often in the absence of speech and any formal instruction.

Other islets of abilities which have been described include musical skill (Wing,1976; Rimland,1978; Applebaum, 1979), mechanical ability (Cain,1969), coordination and balance feats (Wing,1976; Rimland,1978), making clay models (Wing, personal communication).

Temple Grandin, an autistic person has written about her idiosyncratic skill of designing cattle feedlots and ranches. Grandin (1984) describes her ability to form, remember and manipulate visual images. Her extraordinary abilities in this respect have enabled her to become a successful consultant designer of livestock facilities for feedlots, ranches and meat plants.

1.3.2. Islets of abilities in autism and 'idiot savant'

Some of the preceding descriptions of the islets of abilities that have been reported in autistic people are very reminiscent of reports of 'idiot savant' scattered through the earlier mental retardation literature. As early as 1894, Binet referred to the the idiot savant as an individual with one specific outstanding ability, but otherwise functioning at a low intellectual level (Binet,1894). There are various such individual case reports (e.g. Mogridge & Healy, 1912; Byrd,1920; Scheerer, Rothman & Goldstein, 1945). Recent catalogues of individual cases have been collated by several authors (e.g. Hill,1978; Rosen, 1981). The islets of abilities described in the idiot savant literature are very similar to those reported in the autistic literature. These include outstanding rote memory for verbal and visual material, calendrical and mathematical calculation abilities, drawing, art and musical skills. As in the autistic cases, the level of ability is not always reported in the superior range. Sometimes the level of the ability in question is only in or near the normal range.

There have been some attempts at estimating the prevalence of the idiot savant cases in the mentally retarded population. Rothstein (1942) reported an incidence of 2 per 1000 in the retarded population. A more recent survey by Hill (1977) estimated a rate of .06%. However, he does state that this may be an underestimate of the rate in the total mentally retarded population as the survey was only concerned with 300 residential homes for the mentally retarded people in the United States.

It is interesting to question how many of the cases labelled 'idiot savant' would show the behaviour pattern characteristic of autism. Unfortunately, writings on the idiot savant do not generally provide sufficient detail to identify whether the cases or groups described are autistic. Not all autistic children have the islets of abilities of the level to be characterized as 'idiot savant'. Nor do all idiot savant individuals show autistic behaviour, However, there is certainly a strong connection between the two diagnoses. This fact has been acknowledged by several authors (Anastasi & Levee, 1960; Cain,1969; Nurcombe & Parker,1964;

Rutter,1966; Goodman,1972; Hermelin & O'Connor, 1986). Goodman (1972) has infact suggested the term 'autistic-savant' to refer to autistic individuals with islets of abilities to emphasize the overlap between the two phenomena.

The above review shows that there is no shortage of anecdotal descriptions of islets of abilities in autistic individuals. These case descriptions serve the purpose of demonstrating that the phenomenon, however bizarre and puzzling, does exist, and that islets of abilites can occur in a wide range of skills. However, there is very little quantitative information about the level of the skills and the exact nature of the skills. In this type of literature, there has been no attempt to explore the phenomenon in any systematic or scientific way.

1.3.3. Standardized Assessments

The second source of evidence regarding dissociation of cognitive function and the occurrence of islets of abilities in autistic people comes from studies investigating psychological function of autistic subjects on standardized tests. These studies are different from the case studies described above because they do not start off with individuals with a known islet of ability and are not concerned with the behavioural manifestations of islets of abilities. Instead, these studies are designed to explore the patterns of cognitive abilities and disabilities in autistic subjects and various types of control groups. Although not aimed at finding peaks of performance, the studies represent a rich source of quantitative data regarding islets of abilities in terms of broad areas of psychological functioning.

DeMyer et al. (1972) in their studies of intellectual profiles of young autistic children found that a large proportion of autistic children (exact numbers not stated) in their sample showed marked discrepancies in the level of skill on the different psychological tests. The peaks of performance generally occured on fitting and assembly tasks such as peg boards and form boards. The authors refer to these tasks as 'tasks which suggest their own solutions and do not involve language comprehension'. This is only one aspect of the cognitive requirements of such tasks. It is clear that the tasks also require visuo-spatial, perceptual and fine-motor skills.

The most direct and extensive evidence regarding the dissociation of psychological function in autism comes from studies which have analyzed the performance of autistic children on the Wechsler Intelligence Scales. The most well known and widely quoted studies in this respect are those of Lockyer & Rutter (1970), Bartak et al (1975) and Tymchuk et al (1977). Other studies reporting WISC/WAIS profiles include those of Wurst (1976), Wolff & Barlow (1979), Ohta (1987) and Asarnow et al (1987). All these studies show that autistic children show a significantly greater inter-test scatter compared to control subjects who perform more uniformly over the different subtests. In general, the majority of the studies have consistently reported peaks of performance on three subtests: the block design test, the object assembly test and the digit span test. When control groups have been used, the studies show that it is on these three tests that the autistic group obtains higher scaled scores than the control groups. The block design and object assembly tests are generally regarded as tests of visuo-spatial ability. Factor-analytic studies have shown that these tests have a high loading on a space-performance or perceptual-organization factor (Maxwell, 1959; Cohen,1959). The digit span on the other hand is a test of rote memory for numbers, and has a high loading on the freedom from distractibility factor.

The findings regarding the peaks of performance on these tests are generally interpreted as evidence of islets of normal functioning on visuo-spatial and rote-memory skills in autistic people in general. This conclusion assumes that the performance of the autistic groups on these tests is :

a. in the normal range (i.e., that expected for their chronological age);

b. significantly better than their performance on other tests on the same scale (that is, verbal or performance scale as appropriate);

c. significantly better than that of appropriate control groups.

An additional assumption is that these findings are applicable to autistic people of all levels of intellectual ability.

A close analysis of the studies reveals that the results do not always satisfy these assumptions. The extent to which these assumptions are satisfied depends on the overall, verbal and non-verbal IQ levels of the autistic subjects, the types of control groups and the statistical comparisons made. Thus, the conclusions that can be drawn from these studies need to be made more specific. A very detailed analysis of each study is needed for this . This question is taken up in Chapter 4.

1.3.4. Islets of abilities - search for an explanation

The research on the nature of autism has, for the most part, concentrated on the deficits. Until very recently there has been very little scientific interest in the islets of abilities shown by autistic children. It is not surprising therefore that the phenomenon is as puzzling as ever. There is no explanation as to why the dissociation occurs so frequently in autism, or as to how such a high level of performance is achieved on the various islets of abilities by individuals whose general IQ and ability is so poor. The limited attempts at searching for an explanation fall into three categories.

a) One approach has been to offer explanations on the basis of case observation. For the most part, these seem no more than educated guesses which cannot be tested in a scientific manner. This approach does not merit a detailed consideration, but some examples are presented to give the flavour of the approach.

Kanner himself suggested that the rote memory skills shown by his subjects could be attributed to parental pressure and were merely the results of the parents' cramming irrelevant material into their autistic children (Kanner & Eisenberg,1955). Cain (1969) has suggested that some abilities such as calendar counting may have originated through a combination of attempts to achieve mastery through circumscribed activity and the conjunction of a significant dynamic event. Goodman (1972) has proposed that the savant abilites are a result of an early insensitivity to somatic stress. The imprecision of such hypotheses can be appreciated from the concluding statement made by this last author:

> "The specialized abilities and obsessional interests of the "autistic-savant" represent the only small segment of reality to which such children can attach themselves. These activities help fill the intellectual and personal void born of impoverished drives. The mental processes and peculiar skills, according to this interpretation, express the heightened development of intact receptivities and are a natural cognitive outcome of the failure to recognize somatic sensations."
> (Goodman,1972: P. 276)

Defective perceptual mechanisms such as difficulties with inconsistent integration (Ornitz and Ritvo, 1968) and marked preference for proximal over distal receptors (Goldfarb,1956) have also been put forward as explanations for the islets of abilities.

Prior (1979) almost denies the existence of islets of abilities when she states:

> "What are sometimes called 'islets of abilities' are in reality patches of behaviour where the general retardation is a little less severe." (Prior,1979: P. 369)

Prior explains the islets of abilities as overestimation of skill by parents, and suggests that:

> "the willingness to engage in some forms of activity (e.g., jigsaws or music) while refusing others is interpreted as a skill"
> (Prior,1979: P.369)

b) A second approach has been to investigate the cognitive profiles of individuals with particular islets of abilities using standardized tests.

Selfe (1977;1983) has explored the psychological functioning of Nadia and other autistic children with exceptional drawing ability. All these children have shown an extraordinary drawing ability from a pre-school age. Selfe's analysis of their drawings suggests that the ability of these children is qualitatively different from that of normal children, and cannot be explained as a result of normal accelerated drawing talent. All the children drew entirely from memory rather than by copying from pictures and their drawings portrayed accurate perspective , space, depth and photographic realism. The results of standardized intelligence tests such as the British Ability Scales and the Wechsler Scales showed that all the subjects were functioning in the severely retarded range. They all showed a marked dissociation of ability amongst the different tests. Although the level of ability on the various subtests differed between the children, the actual profiles of peaks and troughs in cognitive skills were strikingly similar. The most consistent finding was that all the children showed a marked peak on the block design tests. In most cases, these were the only subtests on which the children scored in the normal range for their chronological age. Other tests on which most (but not all) children performed relatively well were those of spatial imagery, visual and auditory memory and perceptual matching. All the subjects performed well below average on reasoning tasks and on tests of the formal scholastic abilities of arithmetic, spelling and reading.

The author further tested the hypothesis that these children achieved their drawing skill by retaining an eidetic (or photographic) memory of the pictures and drawing around a 'projection' of this image on the paper. An eidetic imagery test was used in which subjects were presented with a picture for 30 seconds and then asked to draw the picture. Only four out of the six subjects cooperated on the task. Their drawings, however, suggested that they were not passive 'copies' of the picture but contained some imaginative and intelligent reconstruction. It is interesting to note that a comparison of the results of the four autistic subjects and normal controls showed that the drawings of the autistic group were more accurate in terms of spatial qualities such as the orientation of depicted objects, their relative size and proportions and their positions relative to other depicted features. Normal children, on the other hand, produced a list of canonical items and disregarded the spatial characteristics.

Cobrinik (1974) has investigated the pattern of functioning on the WISC and ITPA tests of six autistic boys with exceptional rote reading abilities. The study is limited in that it does not use any comparison group, does not report the actual test scores and has not used statistical tests to look at the significance of the inter-test scatter. However, it is worth noting that the peaks of performance were again reported on visual memory and visuo-spatial tasks such as the block design test. The author concluded from these results that the highly developed visual imagery and visual recall skills account for their excellent reading ability. The author suggests that for these children, reading is an extension of pattern recognition and words constitute complex visual patterns in the same way as maps, for example.

The studies which have analyzed WISC and WAIS profiles described earlier also fall into this category. These studies, too , have investigated profiles of psychological functioning in autistic people. The difference is that these studies were not concerned only with autistic individuals with known islets of abilities but used more random samples of autistic subjects. The results of such studies will be discussed in detail in Chapter 4.

Overall, this approach towards explaining islets of ability has served a useful purpose in identifying the broad areas of cognitive functioning on which autistic people demonstrate islets of abilities in the normal range. The most consistently identified area is that of visuo-spatial skill. All the studies in this category suggest that various aspects of this skill are highly developed in autistic individuals. However, this approach takes us no further in understanding the cognitive processes underlying the skill.

c) One of the earliest studies which used an approach to achieve this aim was one by Frith & Hermelin (1969) which investigated the cognitive strategies related to jigsaw puzzle performance of autistic children. In particular, they checked out the suggestion that autistic children are particularly able on jigsaw puzzle tasks and tested the hypothesis that they achieve a high level of performance without looking at the picture. The study used three conditions on a task which simulated the skills necessary for jigsaw puzzle performance. All conditions required the subjects to fit together individual pieces. In one condition, the pieces had straight edges but there were line drawings on the pieces which would run continuously if the pieces were arranged in the right sequence. On the second condition, the pieces had jigsaw puzzle-type jagged edges which fitted together in a particular sequence. There was no guiding line to aid performance on this condition. On the third condition, the pieces had jagged edges and lines which would run continuously if the pieces were fitted together correctly.

The overall results showed that the autistic children were significantly faster and more accurate than normal children. This confirmed the general observations regarding the autistic child's superior ability on jigsaw puzzles. The differences in strategies between autistic and normal children depended on the overall ability level of the autistic subjects. Autistic subjects of higher ability level used the same strategy as the normal children, that is they relied more on information given by line drawings. These groups performed more efficiently in the conditions where these visual cues were present. On the other hand, the less able autistic children performed equally well with or without visual cues. Thus, they demonstrated a strategy that relied on the simple spatial information provided by the jagged edges rather than on the visual information provided by the line drawings. This ability enabled them to perform at the same level as the more able children on the task condition that normal children found more difficult. This was the first experiment to suggest that an abnormal strategy may lead to more efficient performance on some tasks. Moreover, the experiment demonstrated that strategy differences related to overall ability level within the autistic group.

The same group of researchers have carried out a series of experiments (summarized in Hermelin & O'Connor, 1970 and Hermelin & Frith,1971) which throw some light on another islet of ability shown by autistic children, namely the phenomenal rote memory skills described above. Autistic, normal and mentally retarded children, matched on mental age, were required to recall verbal (word strings) and non-verbal (color patterns) material presented either as random strings or as structured patterns. Unlike the control groups, autistic children benefited significantly less from structure. For example, they did not remember meaningful sentences (such as 'we went to town') much better than nonsensical strings of words (such as 'some that a went'). Similarly, their performance on nonverbal material was not aided by the structure provided. They failed to abstract the rules governing the patterns to be replicated. These results suggested that the rote memory skills commonly shown by autistic children are related to a deficit in abstracting rules or key features that normal people use to reduce information when the information to be retained exceeds the immediate memory span. The autistic person relies on an extended form of the uncoded immediate memory system. Hence, they demonstrate very good short-term memories for information that depends on distinct item retention rather than on the abstraction of meaning.

Frith & Snowling (1983) have carried out a detailed study of the reading abilities of autistic children. Their study was designed to investigate the common belief that the reading ability in these children is purely mechanical and merely recognition without comprehension (as suggested by Cobrinik, for example as described above). Autistic subjects were compared with dyslexic subjects of the same reading age and normal subjects of age-appropriate reading ability on cognitive tasks specially designed to test out various hypotheses regarding the specific cognitive skills related to reading. The results demonstrated that the single word reading skills of the autistic children were intact both regarding recognition and comprehension. Their difficulty in abstracting meaning from written text was related to a specific deficit in using contextual semantic cues. There was no problem in using the context for processing syntax. The dyslexic children , on the other hand, had a decoding problem on single word tasks but did not show any difficulty in using the contextual cues to derive meaning. The authors suggested that the specific problem shown by autistic children in using contextual information in reading may be related to a more general deficit of a tendency to ignore context. This study demonstrates that this type of approach is able to pinpoint specific cognitive skills and deficits related to a particular skill. These specific deficits may in fact be general characteristics of the cognition of the autistic child and may eventually explain many aspects of their behaviour.

Shah & Frith (1983), using a similar approach, have investigated more specific cognitive aspects of visuo-spatial skill which, as described above, constitutes the most common broad area of psychological functioning on which autistic children perform particularly well. In this study, the Children's Embedded Figures Test (Witkin et al, 1971) was used. This test requires the subject to locate a simple figure which is graphically embedded in a caricatured drawing of an object (the complex figure). The results showed that the autistic subjects were more accurate at locating the hidden figure compared to mental age matched normal and mentally retarded control children. The performance of the autistic group was at the level expected for their chronological age. The ability to locate embedded figures requires the cognitive ability of overcoming the strong tendency to perceive only the whole. This is normally difficult because of the normal tendency to be captivated by context. The superior performance of the autistic subjects on this task suggests that they are unaffected by this tendency and are able to break up the whole into the constituent details. This study thus identified one component of the visuo-spatial and perceptual islets of ability shown by autistic children. The authors suggested that the ability demonstrated on the basis of this component may in fact be a reflection of a cognitive deficit: that is a tendency to disregard meaningful context. This study again demonstrates the fruitfulness of the approach of identifying cognitive subcomponents in the general islets of abilities. It also suggests that underlying the different islets might be a similar cognitive deficit. For instance, Frith & Snowling (1983), for the quite different ability of reading, also proposed a deficit in the tendency to disregard meaning.

O'Connor and Hermelin (1984; Hermelin & O'Connor, 1986) have investigated the mental strategies used by idiot savant calendrical calculators, musicians and artists. These authors do not relate their findings specifically to autism though they do point out that several of their subjects are autistic or have autistic features. The studies are described here as they illustrate the cognitive approach towards islets of abilities. Calendrical calculators are subjects who can instantly name the day of the week on which any named date falls despite having intelligence levels well below average. In one study, such subjects were asked to name the day for particular dates which had been selected to test out various hypotheses, and the times taken to respond were compared. The results showed that error rate and response times were higher for other years compared to the present year and future years were more difficult than past years. In another study, the authors found that these subjects base their answers on strategies which partly depended on a knowledge of certain rules of the calendar. The authors have concluded, on the basis of these and other studies that the performance of the calendrical calculators and musicians cannot be explained solely as based on memory but also involves some rule-governed strategies. Furthermore, they are able to improvise and use these rules in a flexible way. It is interesting that autistic idiot savants are able to use rule-governed strategies so effectively on particular abilities in view of some previous studies which have suggested that autistic children prefer rote strategies rather than strategies based on rules (Frith, 1970; 1972; Hermelin & O'Connor, 1970). In this context, it would be interesting to compare the strategies used by autistic and non-autistic idiot savants on similar tasks.

1.3.5. Islets of Abilities - Conclusions

1. The phenomenon of dissociation of cognitive function in autism is a valid and reliable one. Its most characteristic description is in terms of the peaks of performance known as 'islets of abilities'. These represent areas of skill on which the autistic person performs at a significantly higher level compared to his or her general level of functioning. The level of performance on islets of abilities varies in different individuals. In some, the performance is outstanding and of a level rarely attainable by normal people. More commonly, the performance is in the normal range. It remains to be seen whether the level of attainment is related to overall IQ level. Islets of abilities have also been used to describe performance which is in the retarded range but represents a peak compared to the rest of the skills of the individual.

It is proposed that the term islet of ability is used only when the performance is at least in the normal range. It is essential that researchers define the level of the islet of ability to avoid confusion. The terms that are used in the present thesis in order to specify the level of attainment are 'normal' ability and 'super-normal' ability. Various studies suggest that the level of the islet of ability may be related to the overall level of intellectual functioning of the autistic subjects.

2. Studies using standardized test batteries have been useful in delineating the broad areas of cognitive function on which autistic people typically show peaks or troughs of performance. The areas in which autistic children have

consistently shown peaks of performance are those of rote memory and visuo-spatial skills.

3. The few studies which have investigated cognitive processing of particular islets of abilities come closest to explaining some aspects of the phenomena. These studies suggest that a similar cognitive deficit may affect processing of all kinds of information and may also, paradoxically, account for the peaks of performance. Some of the studies have suggested that there may be important differences in cognitive strategies between autistic children of differing IQ levels. Unfortunately this lead has not been taken up in the majority of studies in this area and there have been no attempts at relating the general IQ level of the autistic subjects to the cognitive strategies being investigated. This ommision represents a major weakness of these studies.

1.4. Why is it important to study islets of abilities in autism

Amongst researchers in autism, there has been a tendency to take the idea of islets of ability as a bit of a myth or else as an interesting but unimportant fact. This is shown by the literature which consists mainly of case descriptions and very few attempts at extensively or systematically exploring and explaining the phenomenon. This is in marked contrast to the research efforts devoted to the known areas of abnormalities in autism, for example language. Some researchers (e.g. Prior,1979) have gone as far as stating outright that research on islets of ability would be a waste of time and effort.

In the author's view, it is of vital importance to study the assets of a group which is handicapped in many respects. The autistic individuals may well be using unusual and idiosyncratic strategies to achieve high levels of performance on certain tasks. If these strategies can be identified, there may be important practical implications. It may be possible to train autistic people in applying similar strategies to other areas.

As indicated by some of the studies described above, the high level of performance may be a result of abnormal cognitive processing strategies. These may reflect more general characteristics of autism and may affect processing of all kinds of information. If this is the case, it is of paramount theoretical importance to identify the precise nature of such deficits. The identification of precise deficits would also be of practical relevance eventually for teaching and remedial programmes.

Finally, islets of abilities imply marked dissociation of cognitive function. The presence of such a phenomenon challenges theories of general intelligence which assume high inter-corrrelations between most cognitive functions (e.g. Spearman, 1927; Thurstone, 1938; Jensen, 1979). The study of islets of abilities may thus have wide ranging implications for our understanding of the structure of normal intelligence.

1.5. Aims of the Present Studies

The present series of investigations are concerned with a particular area of intellectual function on which autistic people are frequently reported to show islets of abilities. In particular, the studies focus on the peaks of performance shown by autistic people on two subtests of the Wechsler Intelligence Scales. These are the Block Design and the Object Assembly tests. These tests are commonly regarded as tests of visuo-spatial skills. However, this term is just a summary for a conglomeration of skills required for effective performance on these tasks. One aim of the study is to identify the cognitive components of the tasks which contribute to the high level of performance of which autistic people are capable.

Another equally important aim is to relate the findings regarding the levels of islets of abilities and the underlying cognitive processes to the general IQ level and the severity of past and present autistic behaviours of the autistic subjects. This is achieved by contrasting and comparing autistic people of lower and higher non-verbal IQ.

These two autistic groups are first compared in terms of their major clinical symptoms to see if there are any differences. To this aim the groups are compared on first, the severity of autistic behaviour shown before the age of 5 years; second, the course of the autistic behaviours; and, third the current state of their social behaviour. Next, the profiles of the two groups on the Wechsler Intelligence Scales are analyzed in detail. In particular, the level of performance of the two groups on the two critical 'visuo-spatial' subtests is identified and compared with each other and with their respective control group(s). Finally, four experiments are carried out to investigate the cognitive strategies which may account for various levels of achievements on these visuo-spatial subtests.

1.6. Summary of Chapter (1)

This chapter provided the background to the present series of investigations and summarized the overall aims. Literature relevant to the phenomenon of islets of abilities in autism was reviewed. This included descriptive case-studies, fact-finding studies using psychometric assessments, and studies designed to explore the cognitive functions underlying particular islets of abilities. It was concluded that the phenomenon of the islets of abilities in autism is a valid and reliable one, and that studies investigating the underlying cognitive processes come closest to providing pointers towards an explanation of the phenomenon.

CHAPTER TWO

SUBJECTS

2.1 The Autistic group

Twenty autistic subjects featured in these experiments. They were recruited through schools and training centres run by the National Autistic Society. They had all been given a diagnosis of autism by psychiatrists working on behalf of the Society. The author had known all the subjects over a few years and was able to confirm , on the basis of observation and lengthy discussions with staff members, that they all showed the 3 characteristic features of autism, namely, the forms of social impairment, and language abnormalities characteristic of autism and a marked tendency to engage in repetitive obsessional pursuits (Kanner, 1943; Rutter, 1966; Wing, 1976). They had all attended schools for autistic children run by the Society. Appendix (1) gives details of each subject's age, sex, intelligence quotient (IQ), and occupation or placement at the end of the study. The age reported is to the nearest month at the time of testing the subject on the IQ test.

The 2 main criteria for inclusion in the study were age and the level of non-verbal IQ. Only subjects between the ages of 16-25 were used. In fact, with the exception of one older subject, the age range of the subjects was very small, i.e. 16-21 years. There were various reasons for using this particular age-group.

1. There are very few studies of cognitive abilities in autistic adults compared to the wealth of literature on autistic children under the age of 16.

2. The imposition of lower and upper limits to the age

band was to ensure a homogeneous group with respect to age.

3. In these studies of underlying cognitive strategies and abilities, it was important to minimize the confounding effects of different levels of development of the abilities in question.

With regard to the criteria for the level of non-verbal intelligence, only subjects with a non-verbal IQ of 50 or above were included. This was to avoid the possible confounding effects of severe mental retardation, and to enable the use of more sophisticated experimental techniques without the danger of subjects not being able to understand task requirements. The verbal IQ was not considered to be relevant as all the tasks were of a visuo-spatial nature and instructions and responses could be demonstrated non-verbally.

Depending on their age, the subjects were tested on the WISC-R or the WAIS. All except two subjects were able to score on all the subtests. The two subjects who were not able to comprehend task instructions for the majority of the subtests of the Wechsler Scales were tested on the Leiter International Performance Scale. The Leiter IQ was used as an estimate of non-verbal IQ for these two subjects. The Leiter IQ is comparable to the non-verbal IQ of the WISC-R in autistic children (Shah & Holmes, 1985).

The non-verbal IQ of the total autistic group ranged from 57 to 108. This covers a wide range of intellectual ability. In view of the confusion about the possible relationship between mental retardation and autism (reviewed in Chapter 1), and since one of the main aims of the present studies was to clarify this relationship, it was necessary to avoid the pitfalls of previous studies by keeping the autistic group as homogeneous as possible with regard to non-verbal IQ. This was achieved by dividing the autistic subjects into two groups on the basis of non-verbal IQ, with a cut-off point of 85. The groups were defined as follows:-

Group 1 (Average IQ Autistic) comprised 10 autistic subjects with non-verbal IQ between 87 and 108.

Group 2 (Lower IQ Autistic) comprised 10 autistic subjects with non-verbal IQ between 57 and 81.

The cut-off point of 85 was taken as it is one standard deviation from the mean on the WISC-R and the WAIS. In the general population, those with IQs of 85 or above on these test batteries are considered to be of normal intelligence. The percentage of the general population within these limits is shown in Figure 2.1.

Thus, the Average IQ autistic group represented autistic people with at least normal non-verbal IQ. The Lower IQ autistic group represented autistic people with non-verbal IQs in the borderline or the upper end of the mildly retarded range.

Table 2.1 gives the group means, standard deviations and ranges for the 2 groups for chronological age, non-verbal IQ, verbal IQ and full-scale IQ. Appendices (1A and 1B) give individual details of these subject variables and includes information about each subject's occupation at the end of the study. The age reported is to the nearest month at the time of testing the subject on the IQ test.

Figure 2.1

PERCENTAGE OF THE GENERAL POPULATION WITHIN ONE STANDARD DEVIATION OF THE MEAN ON THE WISC-R AND THE WAIS

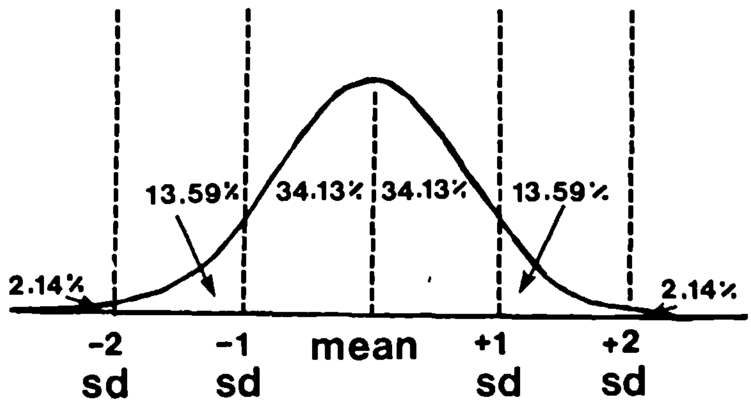


Table 2.1.
Subject characteristics of the two autistic groups

	Average IQ Autistic	Lower IQ Autistic
**N	10	10
male:female	9:1	8:2
Age (Years)		
Mean	18.6	18.5
SD	1.7	3.0
Range	16.4 - 21.2	16.0 - 24.11
Non-verbal IQ		
Mean	96.7	71.0
SD	8.3	6.7
Range	86 - 108	57 - 81
Verbal IQ		
Mean	73.3	56.8
SD	15.8	8.5
Range	48 - 91	45 - 73
Full-scale IQ		
Mean	83.3	62.0
SD	11.0	7.4
Range	62 - 96	50 - 73
Estimate of Non-verbal MA (years)*	>16	10-11

* The overall non-verbal mental age was estimated from tables relating age and mean scaled scores given in the test manuals (Wechsler,1955;1974)

** Although the total number of subjects in each group was 10, the group statistics for Verbal IQ, Full-scale IQ and Non-Verbal MA are based on 9 subjects in each group. This is because the relevant data were missing for one subject in each group. (See Appendix 1A and 1B for details)

The differences between the IQ scores of the two groups are discussed in detail in Chapter 4 , and thus not commented on here. The differences in sex ratio are of interest. The male:female ratio of 4:1 in the Lower IQ group is similar to that generally reported in the total autistic population. However, the male:female ratio of 9:1 in the Average IQ group is much higher but may be generally true of autistic people of higher ability. Several studies (Wing, 1981; Tsai and Beisler, 1983) have reported a tendency for the male:female ratio to decrease at the lower levels of intelligence.

The other interesting difference between the 2 groups is in the nature of their occupation at the end of the study. Five out of the 10 subjects in the Average IQ group had some type of paid employment, 2 in a sheltered setting and 3 in the open market. There was also a possibility that one other subject in this group (RS) would find a job outside with a watch repairer. The remainder of the group, although they attended the adult workshops, all specialized in one of the areas of woodwork, printing or spirography and were reported to have developed a high level of skill in these areas and were able to work with only minimal supervision. In the Lower IQ group, none of the subjects had any paid employment. They all attended the adult workshops where they did woodwork, craftwork, cooking etc., and some also attended numeracy, literacy and pottery classes at the local adult education centre. Three in this group were reported by staff to have a potential for some paid employment and were currently being trained in doing a paper round in the local streets.

2.2. The Control Groups

Various authors have discussed the issue of appropriate control groups for autistic subjects (Yule,1978; Hermelin,1978; Prior, 1979; Frith,1984). These authors have stressed the importance of matching subjects such that any diferences between the autistic and control group can be attributed to autism rather than any other factors such as mental retardation, or developmental level.

In the present studies, the advantage of using very homogeneous groups of autistic people is that each group can be matched to its own control group(s) on very stringent criteria. Since the present studies investigate the underlying cognitive styles and strategies in the two groups of autistic people, it is important to match control subjects on non-verbal IQ or non-verbal mental age or both. Three control groups were used as follows.

2.2.1. Older Normal group - This group consisted of 12 children with normal non-verbal IQ. They were matched with the Normal IQ autistic group on non-verbal IQ. The chronological age of this group ranged from 15.4 to 17.6 years. This age group was selected rather than an older group because they were all still attending a local comprehensive school or a class for school leavers at a college for further education and thus were easier to recruit for the study. Although they were a little younger than the autistic subjects, they were all over the age of 15 and likely to have reached their peak in cognitive ability. Thus, they were considered to be comparable to the autistic group on non-verbal mental age as well as IQ. These subjects were tested only on the non-verbal scale of the WISC-R or the WAIS as that was the most relevant. It was assumed that their verbal IQ and their overall IQ was in the normal range. They were all sociable and friendly youngsters. There was no evidence of any social impairment or oddity. The group means, etc. are given in Table 2.2. The age, sex, and IQ data for the individual subjects are given in Appendix (2). The male:female ratio (15:2) was not significantly different from either autistic group. This is important in studies of visuo-spatial skills in view of the evidence of a male advantage on such tasks in the normal population (Maccoby and Jacklin, 1975).

Table 2.2.
Subject characteristics of the three control groups

	Older Normal	Younger Normal	Lower IQ Non-Autistic
N***	17	16	12
male:female	15:2	15:1	11:1
Age (Years)			
Mean	16.0	10.9	17.8
SD	0.6	0.3	2.5
Range	15.4 - 17.6	10.4 - 11.5	16.3 - 21.10
Non-verbal IQ			
Mean	100.6	105.6	76.3
SD	7.1	5.5	5.5
Range	91 - 114	95 - 114	68 - 85
Verbal IQ*			
Mean	N/A	N/A	74.5
SD			8.0
Range			60 - 88
Full-scale IQ*			
Mean	N/A	N/A	73.7
SD			5.9
Range			62 - 80
Estimate of Non-verbal MA (years)**	>16	10-11	10-11

* Verbal and full-scale IQ were not obtained for the two normal groups. They were assumed to be in the average range, that is between 85 and 115.

** The overall non-verbal mental age was estimated from tables relating age and mean scaled scores given in the test manuals (Wechsler,1955;1974).

*** N given here refers to the total number of subjects in each group. Due to missing data for one subject in the Older Normal group and in the Lower IQ Non-Autistic group, the group statistics are not always based on this total N. In the Older Normal group, N for non-verbal IQ is 16. For the Lower IQ Non-Autistic group, N for Verbal IQ and Full-Scale IQ is 11. (See Appendix (2) and Appendix (3) for details on missing data)

2.2.2. **Lower IQ Non-Autistic group** - This group consisted of 12 subjects with non-verbal IQ in the mildly retarded or borderline range. They were matched to the Lower IQ autistic group on non-verbal IQ, and chronological age. The group details are shown in Table 2.2, and the characteristics for individual subjects are given in Appendix (3). As can be seen, their verbal and full-scale IQ is higher than that of the autistic group. This is inevitable because of the tendency for non-verbal IQ to be much higher than verbal IQ in the autistic group. The sex ratio (11:1) in this group was not significantly different from that of the Lower IQ Autistic group. This control group was particularly difficult to recruit because of the specific non-verbal IQ and age criteria. They all attended various courses for ESN(M) school-leavers in a college for further education. They were all sociable and friendly and appeared to have good verbal communication skills. They had all attended ESN(M) schools and were reported to have specific learning difficulties. However, they all seemed to be quite independent, and on the whole, their behaviour did not seem very different from that of the Older Normal group.

2.2.3. **Younger Normal group** - This group consisted of 16 normal children who were matched with the Lower IQ group on non-verbal mental age. By definition then, they had to be younger as their IQ was in the normal range. They all attended a local primary school. These subjects were tested on the non-verbal scale of the WISC-R. The group details regarding age, sex, IQ and mental age are given in Table 2.2. Details of individual subjects are provided in Appendix

(4). The sex ratio of this group (15:1) was not significantly different from that of the Lower IQ Autistic group or the Lower IQ Non-Autistic group.

Thus, in the experiments on visuo-spatial skills the performance of the Average IQ Autistic group will be compared with that of a normal group of comparable developmental level and non-verbal IQ. This will enable a very stringent test of the 'normality' of the autistic group's cognitive strategies on visuo-spatial tasks, i.e. is the normal non-verbal IQ evidence of normal spared functioning or of unusual strategies or abnormal functioning on some particular subskills constituting the non-verbal IQ. A strict test of this hypothesis is only possible by comparing the autistic group's performance to a normal group who is of similar age (developmental) level and of normal IQ and hence normal cognitive functioning on all subskills constituting the non-verbal IQ.

The performance of the Lower IQ Autistic group will be compared to a normal group of similar non-verbal mental age and a handicapped group of similar non-verbal IQ, non-verbal mental age and chronological age. This will enable us to test whether the cognitive functioning of autistic people of Lower IQ is similar to that of normal younger children or to that of another handicapped group.

2.3. Summary of Chapter (2)

In this chapter, the subjects and matching criteria were discussed. The experimental groups are two groups of autistic subjects. The Average IQ Autistic group comprises

10 autistic subjects with Non-verbal IQ in the normal range, and is matched with a control group of normal subjects on CA, non-verbal MA and non-verbal IQ. The Lower IQ Autistic group comprises 10 autistic subjects with below-normal non-verbal IQ. This group is matched to a control group of normal subjects on non-verbal MA, and to a mildly mentally handicapped group of subjects on CA, non-verbal MA and non-verbal IQ.

CHAPTER THREE

The Relationship of intellectual level to clinical and behavioural variables: a comparison of Average IQ and Lower IQ Autistic subjects

3.1. Introduction

This chapter compares 2 groups of autistic adults, differing in the level of non-verbal intellectual functioning, on various categories of autistic behaviours. The aims are to clarify the nature of the relationship between non-verbal intelligence and autistic behaviour and to provide a context for interpreting the significance of any underlying psychological differences that may emerge between these groups in the later experiments which constitute the major part of this thesis. First, the literature relevant to the relationship between intellectual level and autism is reviewed.

3.1.1. Literature Review

It is well established now that the syndrome of autism can occur at any level of intelligence (Lotter, 1966; Lockyer, 1967; Wing & Gould, 1979). The majority of autistic children show varying degrees of general mental retardation. In fact, prevalence surveys (e.g. Lotter, 1966; Wing & Gould, 1979) have estimated that only about a quarter or a third function in the normal range on intelligence tests. However, as pointed out by Newson et al. (1982) this may well be an underestimate as it is likely that many people functioning in the average or above average range may never be diagnosed or come into contact with any of the services for mental retardation or autism.

One question that has been of interest is the differences between autistic people functioning at different intellectual levels. There are some studies related to the issue but with somewhat limited results.

Bartak & Rutter (1976) compared autistic children with an IQ above 70 to those with an IQ below 70 on various behaviours associated with autism. They found that the characteristic features of autism (social and language abnormalities and ritualistic behaviour) were present in both groups of autistic children but there were many differences in the severity of these. On the whole, the mentally retarded autistic people showed a more severe picture all round. They showed a more severe language delay and more severe social impairment. Also, they were more likely to show behavioural abnormalities and behaviour problems specific to autism and were more likely to develop epilepsy. Although this study draws the global conclusion that there are differences between the two groups of autistic people, various questions remain unanswered. For example, there were three autistic features, namely pronominal reversal, undue sensitivity to noise and presence of rituals which were significantly more frequent in the normally intelligent autistic group. The authors make no suggestion as to why this should be the case when the social and language abnormalities occured more frequently in the mentally retarded group. A major drawback of this study is the use of the gross cut-off point of IQ 70 without imposing any upper or lower limit. This would result in a lot of hetereogeneity within each group. It is possible that a different pattern of differences in behaviour may have emerged if the two groups had been kept more homogenous with regard to IQ.

This latter criticism also applies to a study by Freeman, Ritvo et al. (1981) in which subjects were similarly divided using the cut-off point of IQ 70 and behavioural characteristics were examined using a behaviour observation scale. There was much more overlap in behaviour characteristics between the low-IQ group and a control group of non-autistic mentally retarded children than between the high IQ autistic group and a control group of normal children. Although this study did not compare the two autistic groups directly, the results emphasize the need to differentiate between groups of autistic children of different IQ levels and to use appropriate control groups for each.

DeMyer et al (1974) in a study investigating intellectual disabilites of autistic children whose IQs ranged from borderline (mean of 67) to severely retarded (mean of 26) found a significant positive relationship between IQ and behaviours related to social relatedness, socially adaptive behaviour and communicative speech. Although this study did not include normally intelligent autistic people , the findings regarding differences between autistic children of different levels of retardation are important and indicate that global differentiation of 'mentally retarded' autistic children as done in the studies described above may produce a misleading picture.

Wing & Gould (1979), in an epidemiological study of children with autism and autistic-like conditions have added a new dimension to this question regarding the relationship between autism and IQ by looking at the quality of the social impairment. Their study included non-autistic severely retarded children, and found that the prevalence of social impairment among all children in the population studied who had IQs below 50 steadily increased with decreasing intelligence levels, varying from 40% in the moderately retarded to 80% among those with profound mental retardation. They also found that of all socially impaired children, those with a history of typical autism tended to have a somewhat higher median level of intelligence than those without, even though the majority of both groups were in the severely retarded range.

From the results of the same study, Wing (1981) has reported how the qualitative aspects of social impairment were significantly associated with overall intelligence. For example, at the lower end of the scale of ability , social impairment was manifested in the form of aloofness and indifference. Children of non-verbal ability in the moderately retarded to average IQ range tended passively to accept responses initiated by others, but rarely initiated social approaches themselves. The children who were least handicapped intellectually (with IQs ranging from the mildly retarded to the superior level) showed a very different type of social impairment. Their social problems were very subtle and would be missed on brief acquaintance. They were shown in the naive and one-sided approaches made to others, a tendency to take things literally, an inability to appreciate subtle humour, and so on.

Newson, Dawson & Everard (1982), in a study of the more able autistic people also report a positive relationship between higher levels of intelligence and lessening of autistic features in adult life.

Follow-up studies of autistic people (Lockyer & Rutter, 1969; Rutter, 1970; DeMyer et al., 1973; Lotter, 1974a, 1974b) also show that IQ is a differentiating variable with important implications for prognosis. In general, autistic people with higher IQs make more educational progress, are more likely to be in sheltered or unsheltered employment and also make a better social adjustment in adult life. IQ as a prognostic factor regarding education and employment is not very surprising, but the relationship between IQ and social outcome is important especially for autistic people whose main handicap is the social impairment. Possible reasons for the relationship between social behaviour and overall IQ in autism have been discussed in some detail by Shah & Wing (1986). As pointed out by Howlin (1986), more research using quantifiable measures of social behaviour is needed in order to fully understand the nature of the social impairment and its relation to other factors.

The overall conclusion that can be drawn from this literature is that autistic people of different IQ levels show behavioural differences along both qualitative and quantitative dimensions. One general finding is that autistic children who are more retarded show more severe symptoms of autism and fare less well as adults than autistic children who are less retarded or functioning in the normal range of intelligence. However, there is a suggestion from some of the studies that the relationship between IQ and autism is more complex than that. It is not possible to be more precise about the relationship or explain it due to the limited number of questions addressed by the studies.

All the studies have been concerned with relating intelligence level with behavioural variables. In view of the behavioural differences and especially the link between higher IQ and better social prognosis, an important question is whether there are specific underlying cognitive differences between autistic subgroups differentiated on IQ. There have been no attempts at systematically relating behavioural differences with cognitive aspects.

The studies have usefully differentiated autistic people with different degrees of mental retardation. However, there is very little information about how more able autistic subgroups divided by narrow IQ bands differ. The studies which have included autistic subjects of normal intelligence have tended to make a gross division between mental retardation and normal intellignece.

Another important question that has not been tackled by any of the studies concerns the relationship between intellectual level and the pattern and severity of the autistic characteristics before the age of 5. This is especially important to establish as the behavioural features of classic autism are most clearly and severely manifested before the age of 5 years (Wing,1976; Rutter, 1984). After the age of 5, there is often an improvement in behaviour and changes in the manifestation of the clinical features. Thus, even when the diagnosis of autism is made in later life, the early childhood history is considered of utmost importance (Wing, 1976).

3.2. Outline of the present study

In this study, two groups of able autistic adults differing in their level of non-verbal intellectual functioning are compared on:-

1. autistic behaviours before the age of 5 on the basis of retrospective information provided by parents;
2. the course of the autistic behaviours after the age of 5 years including the current state as rated by parents;
3. the current state of social impairment as rated by observation and interview information.

The study is concerned with 20 autistic adults divided into the following two groups as discussed in Chapter (2):

1. Average IQ Autistic group - comprising all autistic subjects with performance IQs on the WISC or the WAIS between 86 and 108.
2. Lower IQ Autistic group - comprising all autistic subjects with performance IQs between 57 and 81.

Detailed description of these subjects has been given in Chapter (2). Table 2.1 in Chapter (2) summarized the group means on the basic characteristics. The details of individual subjects are given in Appendices (1A) and (1B).

3.3. Autistic behaviour in early childhood (before age 5)

3.3.1. Method

Retrospective information about each subject's pre-school behaviour was obtained from the parents using a structured questionnaire. The questionnaire, together with an explanatory letter and a stamped addressed envelope were distributed to the parents via the principals of the respective schools or hostels attended by the subjects. The principals were familiar with the questionnaire, and were available to answer any parents' queries. They were unlikely to introduce any bias as they were not aware of the purpose of relating the answers to intellectual level. There was no reason to suppose that the parents gave untruthful answers or intentionally exaggerated or played down any particular characteristics. The subjects were all adolescent or adult and hence the answers could not have any consequences for their educational placement, diagnosis or treatment.

On the other hand, it is valid to question the parents' memory for past events. This is a problem in any design that relies on retrospective data. However, it may not be such a problem for the types of questions asked here. They refer to abnormal characteristics which probably caused the parents a lot of concern and worry. The parents are likely to have vivid memories of their childrens' infancy and early years. As reported by Wing (1976), these are the hardest years for parents of autistic children. If there are systematic differences between the groups the doubt about the accuracy of information would be minimal as there is no reason to suppose selective and systematic differences in recall by the 2 groups of parents. This method of collecting retrospective information from parents of handicapped and normal children by means of postal questionnaires has been used successfully in several studies (Wing,1969; 1971).

Early Childhood Questionnaire (ECQ)

This questionnaire was designed specially for the study in consultation with Dr. Lorna Wing. It included the key behaviours essential for diagnosis and also other typical behaviours commonly shown by autistic children in early childhood. The questions were based on the descriptions of Kanner (1943) and Wing (1976) and on the Handicaps, Behaviour and Skills Schedule (HBS) which is a questionnaire used to structure interviews with parents. It is used either for present behaviour or for taking a history of childhood development (Wing & Gould,1978). No reliability measures were taken for the ECQ. However, reliability of the HBS, from which most of the items have been taken, has been found to be very high (70% and above for inter-interviewer and inter-informant, Wing & Gould, 1978).

There were 2 sections. Section 1 consisted of 19 questions about abnormal behaviours shown by autistic children. For each question, the parents had to indicate whether or not their child had shown the particular behaviour before the age of 5. If so, they had to state the age it had started and stopped. This was a check to ensure that the behaviour mentioned had occured before the age of 5. They were also required to rate the behaviour on a 4 point scale of severity. This was defined as follows:-

very severe - The behaviour occured constantly (evident at least 6 times daily);

severe - The behaviour occured between 1 - 6 times daily;

quite severe - The behaviour was evident less than daily but at least once a week;

mild - The behaviour was evident less often than once a week.

The last question in section 1 was concerned with special skills. There was no rating of severity on this question. Section 2 consisted of 8 questions about imaginative and social behaviours which are very obvious in normal children but often not shown by autistic children. For these questions, the parents were asked to state whether or not their child had ever shown this behaviour and if so, the ages at which it had started and stopped.

For both sections, the parents were also asked to give examples of specific behaviour if possible. The items of the questionnaire are listed below briefly. A copy of the actual questionnaire as sent to the parents is included in Appendix (5). It is important to note that none of the questions was exclusive, i.e. a subject could be rated as having shown all the behaviours. Thus, for example, on the social impairment questions, a subject could have a rating of presence on all the different types of social impairment, i.e. aloof, passive,odd,etc.

Summary of Items of the ECQ

The items are described here very briefly. The reader is referred to the copy of the questionnaire in Appendix (5) if further definition of any item is required.

Section 1. Abnormal Behaviours

1. Social Impairment

This included 3 questions (a, b and c below) to cover the possible manifestations of social impairment described by Wing & Gould (1979), 3 related questions (d, e and f)about social withdrawal and 2 questions (g and h) about eye-contact.

a. Markedly aloof and indifferent
b. Passive response if others initiate
c. Indiscriminate response - 'odd' social interaction
d. Pushing people away
e. In a world of their own
f. Going to people only for physical contact
g. Avoidance of eye-contact by covering eyes or turning whole body away
h. Avoidance of eye-contact by looking through others

2. <u>Abnormalities of Language</u>

a. Immediate echolalia - this refers to the tendency to repeat words and phrases spoken by others as soon as they are heard
b. Delayed echolalia - this refers to the repetition of words or phrases after some delay
c. Pronominal reversal
d. Repetitive conversation - this refers to the tendency to go on and on about a particular topic; It requires the expressive language ability to be at least at the level of carrying out a simple conversation
e. Absence of babbling

3. <u>Stereotypic Behaviours</u>

a. Unusual motor stereotypies, for example flapping, spinning
b. Simple repetitive behaviours with objects

e.g.flicking pieces of string, tapping 2 objects, rolling pieces of cotton, etc.

c. Elaborate repetitive behaviours - this refers to repetitive behaviours requiring a higher level of cognitive skill than b; e.g. arranging objects in patterns, listening to pieces of music again and again,etc.

d. Special routines/rituals invented by the subject.

e. Undue distress if everyday routines changed

4. Presence of Special Skill(s)

Section 2. Normal social and imaginative behaviours

1. Imaginative activities
   a. Simple pretend play using toys
   b. Elaborate pretend play
   c. 'Dressing-up' and 'make -believe' games
   d. Imitating mother's actions by pretending

2. Social and Communicative Behaviours
   a. Enjoying the company of peers
   b. Lifting arms to show eagerness to be lifted
   c. Greeting father/mother on their return to house
   d. Going through a stage of babbling

3.3.2. RESULTS

Twenty questionnaires were sent out. Of these, 2 were not returned. The following analysis is thus based on 18 questionnaires. The two subjects for whom the questionnaires were not completed were both in the Average IQ group.* The results were analyzed by using non-parametric contingency tests for small samples.

The questions in Section 1 were scored on the basis of the severity ratings. The 4 points on the scale of severity were accorded the values of 1-4, 1 being mild and 4 being very severe. If the behaviour was not present,the score was 0. All the questions were scored individually in this way. The questions in Section 1 were simply rated as 'present' or 'absent'. The raw scores for each subject for each question are shown in Appendix (6). For the purposes of statistical analysis, the severity scale was collapsed to form a 2 point scale as follows:-

1. behaviour present in severe form = scores 3 or 4
2. behaviour absent or present only in mild form = scores 0,1 or 2

In tables 3.1, 3.3, 3.4, 3.6, and 3.7 below, the statistical comparison applies to the number of subjects showing the behaviour in a severe form .

1. Social Impairment

The results are summarized in Table 3.1. All the subjects except one in the Lower IQ group had at some stage in their development shown the type of social impairment described by Kanner, namely the classic aloofness and indifference. However, it was shown as a severe behaviour significantly more frequently in the Average IQ group. This was the only behaviour in the section on social impairment on which the groups differed significantly. Both groups had shown the passive type of

* This represents a huge loss of data in one group. It is possible that the results may have been different if this had not occured.

social impairment, in addition to the aloofness, to some degree but rarely was this rated as severe. The 'odd' type of social impairment had been shown by a very small percentage in each group and was only rated as severe in one instance in each group.

Wing & Gould (1978) described the categories of aloof, passive and odd as discrete categories and rated their subjects on one of these to the exclusion of others. In the present study, the questionnaire had been structured so that none of the categories were exclusive. Thus, the parents could have rated the subject on either or all of the categories. This produced some interesting results regarding the overlap of the 3 categories. Table 3.2. shows the numbers of subjects for the various combinations of categories. It can be seen that in both groups the subjects have been reported as showing more than one type of social impairment. This tendency was more common in the Average IQ group. Seven out of the 8 in this group were rated on more than one category compared to half of the Lower IQ group.

All 10 subjects in the Lower IQ group, and 7 out of the 8 in the Average IQ group, were rated as being in a world of their own. This seemed to occur frequently enough to be rated as a severe behaviour for a higher proportion of the Average IQ group. However, the difference between the groups did not reach significance. Half the subjects in the Average IQ group and about a third in the Lower IQ group tended to push people away and the same proportions tended to approach people for physical contact only. However, these behaviours rarely occurred frequently enough to be rated as severe in either group.

TABLE 3.1.
Social Impairment before age 5

	Average IQ Autistic (N= 8)				Lower IQ Autistic (N=10)		
	No. SS with beh.	(out of 10)*	No. with Severe	(10)	No.SS with beh.	No. with Severe	P**
A.							
1. Aloof	8	(10.0)	7	(8.8)	9	2	0.01
2. Passive	7	(8.8)	2	(2.5)	5	1	ns
3. Odd	3	(3.8)	1	(1.3)	2	1	ns
Any problem under A	8	(10.0)	7	(8.8)	10	3	
B.							
1. Pushing away	4	(5.0)	0		3	1	ns
2. in own world	7	(8.8)	3	(3.8)	10	1	ns
3. physical contact only	4	(5.0)	1	(1.3)	2	0	ns
Any problem under B.	8	(10.0)	3	(3.8)	10	2	
C.							
1. Looking through	2	(2.5)	1	(1.3)	6	1	ns
2. turning head	5	(6.3)	1	(1.3)	6	1	ns
Any problem under C.	6	(7.5)	2	(2.5)	8	2	

*Instead of percentages, proportions out of 10 are given for the Average IQ Autistic group for ease of comparison with the Lower IQ Autistic group.

**The statistical comparisons using the Fisher Exact Test apply only to the frequencies with severe rating in this Table and the following Tables: 3.3, 3.4, 3.6, 3.7.

TABLE 3.2.
Distribution of subjects in the social impairment categories before age 5

	Average IQ group (N=8)	Lower IQ group (N=10)
Aloof only	1	4
Passive only	0	1
Odd only	0	0
Aloof & Passive	4	3
Aloof & Odd	1	2
Passive & Odd	0	0
Aloof, Passive & odd	2	0
Total	8	10

TABLE 3.3.
Language abnormalities before age 5.

	Average IQ Autistic (N=8)				Lower IQ Autistic (N=10)		
	No. SS with beh.	(out of 10)	No. with Severe	(10)	No.SS with beh.	No. with Severe	P*
1. Immediate echolalia	6	(7.5)	4	(5.0)	2	0	0.02
2. Delayed echolalia	5	(6.3)	3	(3.8)	2	0	ns
3. Pronominal reversal	4	(5.0)	3	(3.8)	4	1	ns
4. Repetitive speech	4	(5.0)	4	(5.0)	3	0	0.02

* In the analysis on this table and in Tables 3.7, 3.8 and 3.10, the probability level of less than 5% has been taken as indicating a significant difference between the groups. Although this carries a risk of finding a significant result by chance, the use of this level of significance is justified as the tests used are non-parametric and in every case, the differences between the groups are quite large.

Although there were no significant differences in the avoidance of eye-contact, it was interesting to note that the Average IQ group avoided eye-contact by 'looking through others' more frequently than by covering eyes or turning whole body away. There was no such difference in the Lower IQ group.

2. Language Abnormalities

These results are summarized in Table 3.3. All the subjects except one in each group (i.e. 7/8 in the Average IQ group and 9/10 in the Lower IQ group) had some language before the age of 5. However, half the Average IQ group and 6 out of the 10 in the Lower IQ group had not gone through a stage of babbling.

At least half of the subjects in the Average group had shown all the types of language abnormalities , and three quarters had had immediate echolalia. The picture was different for the Lower IQ group. For them, the most common problem was that of pronominal reversal and even this occurred in only 4 out of the 10. Immediate echolalia and repetitive conversation were present in a severe form significantly more frequently in theAverage IQ group. In fact,these were never rated as severe in the Lower IQ group.

3. Stereotypic and Repetitive Behaviours

These results are summarized in Table 3.4. The types of stereotypic behaviours noted by Kanner such as spinning, flapping, etc. occured frequently in both groups but were rated as severe significantly more frequently in the Average group. The same was true for elaborate repetitive activities

TABLE 3.4.
Stereotypic and repetitive Behaviours before age 5

	Average IQ Autistic (N=8)				Lower IQ Autistic (N=10)		
	No. SS with beh.	(out of (10)*	No. with Severe	(10)	No.SS with beh.	No. with Severe	P
1. Spinning, etc.	8	(10.0)	5	(6.3)	7	1	0.01
2. Simple Repetitive	7	(8.8)	2	(2.5)	9	1	ns
3. Elaborate Repetitive	8	(10.0)	6	(7.5)	7	1	0.01
4. Own routine & rituals	2	(2.5)	1	(1.3)	5	2	ns
5. Distress if change	7	(8.8)	3	(3.8)	9	1	ns

TABLE 3.5.
Special skills before age 5

	Average IQ group (N=8)	Lower IQ group (N=10)
Type of skill	No. of SS	No. of SS
Drawing	2	1
Jigsaws	2	2
Mechanical	2	1
Reading	0	3
Memory	1	2

such as arranging objects in lines or patterns, or listening to records over and over again. Both groups showed simple repetitive behaviours and distress if routines were changed, but these were rarely rated as severe in either group.

4. Special Skills

These were present in a high proportion of subjects in each group. Table 3.5 lists the type of special skills shown. The majority of the special skills were of a visuo-spatial nature. There was not much difference in the types of skills shown by the two groups. It is interesting to note that none of the Average IQ group were especially good at reading whereas 3 subjects in the Lower IQ group were.

5. Imaginative Activities

None of the subjects in the Average IQ group and only one subject in the Lower IQ group had shown any type of pretend or imaginative activities in childhood (see Table 3.6).

6. Other Social Behaviours

None of the subjects in the Average IQ group had shown any of the normal 'social' behaviours such as enjoying the company of similar aged children, lifting arms to be picked up and greeting parent on arrival. Subjects in the Lower IQ group showed these behaviours to varying degrees. These results are summarized in Table 3.7.

TABLE 3.6.
Imaginative activities

	Average IQ group (N=8)	Lower IQ group (N=10)	P
	No. of Subjects	No. of Ss	
Imitating actions	0	1	ns
Simple pretend	0	1	ns
Elaborate pretend	0	1	ns
Make-believe games	0	0	ns
Any type of pretend play	0	1	ns

TABLE 3.7.
Other social behaviour

	Average IQ group (N=8)	Lower IQ group (N=10)	P
	No. of Subjects	No. of Ss	
Company of peers	0	5	0.05
Lifting arms	0	3	ns
Greeting parents	0	4	ns
Any of the above	0	5	ns
Babbling	4	4	ns

3.3.3 DISCUSSION

All subjects in both the groups (i.e. 8 in the Average IQ group and 10 in the Lower IQ group) were rated as having in their early years one or more of the various social impairments described in the ECQ. This is not surprising given that all the subjects had a diagnosis of autism. In fact, in both the groups the most frequently rated behaviours, regardless of severity, were the tendency to be aloof and indifferent to other people and to appear to be in a world of their own. There was, however, a highly significant difference between the groups in the severity of the classic aloofness. The Average IQ group had severe ratings on this variable significantly more often than the Lower IQ group. This finding seems contradictory to the findings frequently reported in the literature concerning the relation between IQ level and the severity of autistic symptoms. All the studies reviewed in Chapter 1 suggest that severity of the social impairment decreases as IQ level increases. Also, there is a strong tendency for social impairment to change in form and apparently improve with age (Wing, 1981; Shah, 1986). In all these studies which have investigated the relation between IQ and severity of the social impairment, the majority or all of the subjects have been over the age of 5 and often much older. It is well established that IQ is an important prognostic factor with regard to the severity of the social impairment (Rutter, 1970; Lotter, 1974), that is autistic people with higher IQs are more likely to show an improvement in social impairment and other symptoms. Also, there is a strong tendency for autistic behaviours to improve with age. The studies which investigate the relation between IQ and autism at a given point in time are able to comment only on current state and not on initial state. The present study refers specifically to the severity of symptoms before the age of 5. Thus it adds to the previous studies rather than contradicts them. The interesting fact brought to light by the present study is that typically autistic subjects of non-verbal IQ in the normal range are likely to start off with a more severe social impairment than those of borderline or mildly retarded intellectual level regardless of how they do later in life.

On the section on language abnormalities, the Average IQ group showed both immediate echolalia and repetitive conversation significantly more severely. Repetitive conversation, by definition, requires an adequate level of expressive language. The difference between the groups may be due to differences in the level of language. It is possible that the Average IQ group, by virtue of their higher intelligence, had higher verbal ability and thus were more likely to engage in repetitive conversation. Immediate echolalia, on the other hand, does not require similar language competence. Since almost all the subjects (except one in each group) had some language, the difference in immediate echolalia cannot be explained away.

The Average IQ group were also significantly more likely to show certain stereotypic behaviours in a severe form. These were the motor behaviours and the elaborate repetitive behaviours, both of which are very characteristic of classically autistic children. The most frequently reported motor stereotypies were unusual movements of the hands or arms such as flapping. The most common elaborate repetitive behaviours were arranging objects in patterns and listening to the same pieces of music over and over again. All these occurred in the Lower IQ group as well but rarely were they rated as severe. Elaborate repetitive behaviours, by definition, require a certain amount of cognitive ability. Thus, it may not seem surprising that these occur more frequently in the Normal IQ group. However, the fact that they did occur in 7 out of the 10 in the Lower IQ group (although in severe form in only 1 of these) suggests that subjects in the Lower IQ group did have adequate cognitive skill to indulge in the elaborate repetitive routines. The fact that they did not do so frequently enough to be rated as severe is unlikely to be related to a lack of cognitive competence.

The findings with regard to special skills would have been far more useful if some information about the quality of the special skill had been obtained. There were no differences between the groups in the frequency of occurence of the skill, or the type of skill shown. It is noteworthy that the majority of the special skills shown required good visuo-spatial abilities.

There were no differences between the groups on the absence of imaginative activities. All the subjects rated except 1 in the Lower IQ group showed a complete absence of any sort of pretend or imaginative activity. It is worth noting that on Table 3.6 it is the same subject who has been rated on the 3 pretend items rather than a different subject on each. This finding corroborates the well established phenomenon of the lack of pretend or imaginative actvity in most typically autistic people (Wing et al.,1977; Riguet et al.,1981;

Ungerer & Sigman,1981; Gould,1986; Baron-Cohen,1987).

Finally, the Average IQ autistic group were significantly less likely to enjoy the company of peers than the Lower IQ group. There were no significant differences between the groups on the other social behaviours. However, it is interesting that none of the subjects in the Average IQ group showed any of the other normal behaviours that were rated whereas some subjects in the Lower IQ group showed one or more of these.

Comments on some individual subjects

On the whole the data for individual subjects fitted the overall picture of each group reported above. However, there were three subjects in the Lower IQ group who seemed to have somewhat different behaviour from the rest of the group and are worthy of special comment.

MP was the only subject in the whole study who was reported not to have ever shown the classic aloofness. She was rated as having a tendency to be passive and to be in a world of her own. She also did not have any elaborate repetitive routines. She was the only subject who had shown all the other normal social behaviours rated, namely enjoying the company of peers, lifting arms in anticipation of being picked up and greeting parents on arrival. Furthermore, she was the only subject to show the 3 types of imitative and pretend activity. Thus, although there is no doubt that MP is clearly autistic now, she seems to have had a very mild form of autism in childhood and remains a curious subject in the present study.

A second subject of particular interest was DP. He was the only subject in the Lower IQ group who had shown in a severe form the 2 features that Kanner & Eisenberg (1955; 1956) regarded as essential for the diagnosis of autism, namely aloofness and elaborate repetitive routines.

The third subject, UL, also in the Lower IQ group, had shown severe aloofness but his elaborate repetitive routines were not rated as severe.

3.3.4. Conclusions

Thus, the overall picture that emerges from this retrospective study is that autistic subjects with performance IQs in the normal range show a more severe form of Kanner's classic autism than autistic subjects with performance IQ below normal but above mild retardation level. The interesting question is how do the 2 groups fare in later life and what do these differences really mean in terms of underlying psychological functions. The first question is taken up in the remainder of this chapter.

3.4. The course of the autistic behaviour after the age of 5 years

3.4.1. Method

The information regarding the course of the autistic behaviour in the two groups of autistic subjects after the age of 5 years was available from the Early Childhood Questionnaire completed by parents. For each question, parents had been asked to state the age at which the behaviour in question started and stopped. Parents had usually given ages and sometimes general categories such as 'early teens', 'late teens' or 'adolesence'. If the behaviour had not stopped, they had stated that it still continued and had usually made some comment about the severity or the nature of the behaviour.

3.4.2. Results

The answers given by parents regarding the ages when behaviours started and stopped could be grouped into 4 categories as follows:-

Approximate Ages

1. 5-7 years
2. 8-12 years
3. 13-16 years
4. 16+ years (up to the time of the study)

In some cases, the behaviour had started after the age of 5. These behaviours had not been counted as present in the anlaysis in the previous section, but are of interest here. Tables 3.8 to 3.12 summarize the results for each item of behaviour for the 2 groups. The text comments on the main findings regarding the course of the behaviour in the 2 groups. Wherever numbers permit, the differences between the groups are analyzed statistically by collapsing categories and using 2x2 contingency table analysis. Two types of analysis were carried out:

1. to compare the differences between the groups regarding the age at which the behaviour stopped. In order to obtain a 2X2 table the comparison is made between the proportions of subjects still showing the behaviour after a particular age period. This comparison is not made if the behaviour has not stopped for the majority of the subjects in either group.
2. to compare the proportions of subjects in the 2 groups still showing the behaviour. This comparison is not made if

most of the subjects in both groups have stopped the behaviour.

1. The 3 types of social impairment : aloof, passive, odd (see Table 3.8)

a. Aloof and Indifferent

(ie. 7 out of 8)

All subjects except one in the Average IQ group and two in the Lower IQ group had shown recovery from this most severe form of social impairment by the time they were over 16 years old. However, there were clear differences in the ages at which the aloofness had stopped. In the Average IQ group, all the subjects had shown recovery in the years from 5 to 7. By contrast most of the subjects in the Lower IQ group had recovered more gradually over the period from 8 to 16 years. There was a significant difference ($P<.05$, Fisher Exact 2X2 contingency analysis) between the numbers in the 2 groups showing aloofness after age 7 years.

b. Passive Response

In the Average IQ group, only 2 people still showed this type of social behaviour after 16 years. By contrast, in the Lower IQ group, this type of social behaviour was still shown in 5 out of 6 people who had shown it in earlier childhood. In 2 cases, this behaviour had started between the ages of 9 and 10 years and still continued. The differences between the groups regarding the age at which the behaviour stopped and the tendency to still show the behaviour were not significant.

c. Odd Social Interaction

This had been shown in few people in either group before the age of 5. It developed in 3 more people in the

TABLE 3.8.
Course of social impairment

	N	ONSET: before 5	after 5	IMPROVEMENT DURING YEARS: 5-7	8-12	13-16	continues	P*
A. Aloof & Indifferent								
AIQ	8	8	0	7	0	0	1	.05
LIQ	10	9	0	2	3	2	2	
B. Passive Response								
AIQ	8	6	0	2	2	0	2	ns
LIQ	10	4	2	0	1	0	5	
C. Odd Interaction								
AIQ	8	3	0	3	0	0	0	.05
LIQ	10	2	3	0	0	0	5	

*The statistical comparison in this table and tables 3.10, 3.11,3.12 is between the numbers in each group who continue to show the behaviour after age 7.

TABLE 3.9.
Distribution of subjects in the social impairment categories after age 16

	Average IQ group (N=8)	Lower IQ group (N=10)
Aloof only	0	1
Passive only	1	2
Odd only	0	3
Aloof & Passive	1	1
Aloof & Odd	0	0
Passive & Odd	0	2
Aloof, Passive & odd	0	0
None of the above	6	1
Total	8	10

Lower IQ group around the ages of 11 to 12. It did not continue into adulthood in any of the subjects in the Average IQ group but did in all the 5 people who had shown it in the other group. The differences between the groups in the proportion of subjects showing this type of social impairment after the early school years and still showing it were both significant ($P<.025$).

It is worth considering the results of all the 3 types of social impairment together . A significantly higher number of subjects in the Average IQ group stopped showing any of the 3 types of social impairment rated on the ECQ after the age of 16 years compared to the Lower IQ group ($P<.01$). Specifically, only 2 of the 8 subjects in the Average IQ Group were still rated on any of these categories compared to 9 out of the 10 subjects in the Lower IQ group. Table 3.9 shows the distribution of the subjects in the various categories and combinations of categories. Out of the 11 subjects still showing aloof, passive or odd behaviour 7 were rated as showing one type only. Three subjects in the Lower IQ group and 1 subject in the Average IQ group still had combinations of two types and none showed all three. Under age 5, 12 out of the total of 18 subjects showed combinations of two or more types.

<u>2. Other related social abnormalities</u> (see Table 3.10)

d. Pushing people away, being in their own world and going up to people only for physical contact

On all these behaviours, there had been almost a total recovery rate occuring mostly from 5 to 7 years in the Average IQ group and from 5 to 12 years in the Lower IQ

TABLE 3.10.
Course of other social abnormalities

	N	ONSET: before 5	ONSET: after 5	IMPROVEMENT DURING YEARS: 5-7	8-12	13-16	continues	P
D. Pushing People Away								
AIQ	8	4	0	3	0	0	1	ns
LIQ	10	3	0	1	1	1	0	
E. Own World								
AIQ	8	7	0	6	0	0	1	.01
LIQ	10	10	0	2	7	0	1	
F. Physical Contact Only								
AIQ	8	3	0	3	0	0	0	ns
LIQ	10	2	0	1	1	0	0	
G. Avoiding Eye-Contact By Turning Away								
AIQ	8	2	0	0	0	0	2	.05
LIQ	10	6	0	0	1	0	5	
H. Avoiding Eye-Contact By Looking Through People								
AIQ	8	5	0	5	0	0	0	ns
LIQ	10	6	0	4	0	0	2	

TABLE 3.11.
Course of language abnormalities

	N	ONSET: before 5	ONSET: after 5	IMPROVEMENT DURING YEARS: 5-7	8-12	13-16	continues	P*
A. Immediate Echolalia								
AIQ	8	6	0	1	2	0	3	ns
LIQ	10	2	1	1	1	0	1	
B. Delayed Echolalia								
AIQ	8	5	0	1	0	0	4	ns
LIQ	10	2	0	1	0	1	0	
C. Pronominal Reversal								
AIQ	8	4	0	0	2	1	1	ns
LIQ	10	4	1	0	1	0	2	
D. Repetitive Speech								
AIQ	8	4	0	0	0	1	3	ns
LIQ	10	3	1	0	1	1	2	

Group. A significantly (P<.01) higher proportion of subjects in the Lower IQ group showed the tendency to be in their own world after age 7 years compared to the Average IQ group, the majority of whom stopped showing this during the period from 5 to 7 years. One in each group still seemed to be in a world of their own sometimes. This one subject in the Average IQ group was in fact the only subject who was rated as still showing many of the social abnormalities, including aloofness, pushing people away, and responding passively.

e. Avoiding eye-contact by turning away

Only 2 people in the Average IQ group had shown this before the age of 5 and they still continued to do this as adults. One of them was the same subject who still showed all the other social abnormalities. Similarly 5 out of 6 subjects who had shown this in the Lower IQ group before age 5 still continued. Only 1 subject in the Lower IQ group had shown improvement on this. There was in fact a significant difference (P<.05) between the number of subjects in each group who still showed this behaviour.

f. Avoiding eye-contact by looking through people

All 5 subjects in the Normal IQ group and 4 out of 6 subjects in the Lower IQ group who had shown this type of avoidance of eye-contact stopped doing so between 5 and 7 years. The 2 remaining subjects in the latter group still continue to do it now. The difference between the groups was not significant.

3. Language Abnormalities (see Table 3.11)

Half of those in the Average IQ group who had shown immediate echolalia before the age of 5 still tended to do so sometimes. In the other group, immediate echolalia had occured only in 2 people before the age of 5 and both stopped this by age 13. One subject in the Lower IQ group who developed immediate echolalia around the age of 10 still had this problem.

Four of the 5 subjects in the Average IQ group who had delayed echolalia still had it at the time of the study. Delayed echolalia was rare in the other group before the age of 5 and by the time of the study it was not present in any subject.

There was no significant difference between the groups regarding improvement in pronominal reversal. One out of the 4 subjects who showed this before age 5 in the Average IQ group and 2 out of the 4 in the Lower IQ group still reversed pronouns at the time of the study.

Three of the 4 showing repetitive speech in the Average IQ group still show this tendency sometimes. In the Lower IQ group 2 subjects had stopped doing so, 1 had developed it later around the age of 10 and 2 still showed the problem at the time of the study.

The differences between the groups on the proportions of subjects still showing the behaviour abnormalities rated were not significant on any of the language items. Similarly there was no significant tendency for the Average IQ group to show improvement in the early school years. When improvement occured it tended to be at any time in either of the groups.

<u>4. Stereotypic and Repetitive Behaviours</u> (see Table 3.12)

The motor stereotypies such as flapping and spinning which were shown by all the subjects in the Average IQ group continued to occur sometimes in three quarters of these

TABLE 3.12.
Course of stereotypic and repetitive behaviours

	N	ONSET: before 5	after 5	IMPROVEMENT DURING YEARS: 5-7	8-12	13-16	continues	P
A. Motor Stereotypies								
AIQ	8	8	0	1	1	0	6	NS
LIQ	10	6	0	0	1	2	3	
B. Simple Repetitive Behaviours								
AIQ	8	7	0	2	1	0	4	NS
LIQ	10	9	0	1	6	0	2	
C. Elaborate Repetitive Behaviours								
AIQ	8	8	0	1	1	0	6	NS
LIQ	10	7	3	2	2	0	6	
D. Own Routines and Rituals								
AIQ	8	2	0	2	0	0	0	NS
LIQ	10	5	0	1	3	0	1	
E. Distress if routines changed								
AIQ	8	7	0	1	4	0	2	NS
LIQ	10	9	1	1	3	0	6	

subjects. They continued in half of the Lower IQ group.

Simple repetitive behaviour with objects decreased significantly in both groups but more so in the Lower IQ group. In the majority of the subjects in the Lower IQ group they stopped between 8 and 12 years. There was no particular pattern in the time of improvement in the Normal IQ group.

Three quarters of the Average IQ group continued to show elaborate repetitive behaviours. Two subjects had stopped showing these completely, one between 5 and 7 years and one between 8 and 12 years. Three subjects in the Lower IQ group started showing elaborate repetitive behaviours after the age of 5 (between the ages of 10-12). However, 4 out of the 10 subjects in this group stopped doing so by age 16 years. The differences between the groups were not significant.

Only one person in the Lower IQ group still had self-invented rituals at the time of the study.

The majority of the subjects in the Average IQ group who had shown distress to change in routine stopped doing so by age 12. In contrast, 6 out of the 10 subjects in the Lower IQ group continued to show this problem even though to a lesser extent. Those who stopped tended to do so from 8 to 12 years. Thus, there was no significant difference between the groups regarding the age at which the behaviour stopped. The difference between the proportion of subjects in each group who continued this behaviour did not reach significance.

3.4.3. Discussion

Overall, there is considerable improvement in autistic behaviours after the age of 5 in both groups. This general finding corroborates the reports of other authors

(Wing,1976; Rutter, 1984; Kanner,1971; Rimland,1964). The present findings, in addition, bring out certain differences in the patterns of onset, improvement and recovery in 2 groups of autistic subjects of differing overall non-verbal intelligence.

The most interesting differences concern the ratings of social abnormalities. In both groups, there is a marked lessening of the tendency to be aloof and indifferent to other people. All subjects had been rated as showing some degree of aloofness and indifference before the age of 5, but, after age 16, almost all were reported as not showing this extreme form of social impairment at all. This corroborates reports by Wing (1981) and Shah (1986) of the tendency for autistic people to change in their manifestation of the social impairment with age. The majority of the Average IQ group were not rated on either of the other types of social impairment, i.e. passive and odd. Most subjects in the Lower IQ group, however, still showed a tendency to respond passively or oddly or both. Thus, the Average IQ group who showed a more severe social impairment before the age of 5 seemed to have improved the most, and to have moved beyond the limits of the scale of social impairment used in the study . The Lower IQ group, who did not show such a severe social impairment before the age of 5 had also improved in their quality of social interaction but not as much as the other group. These findings raise the question of the applicability of the Wing & Gould (1979) scale of social impairment in its present form to autistic adults of non-verbal IQ in the normal range. It must be pointed out that the authors have never claimed the scale to be applicable universally to the autistic population.

The other major difference between the groups is the age at which improvement in social interaction occurs. The Average IQ group , who had shown all the social abnormalities in a more severe form before the age of 5, showed the greatest improvement between 5 and 7 years of age. Whenever any item of social abnormality was reported to have stopped in this group, it was always within this age range. In the Lower IQ group, on the other hand, the social abnormalities were present in a milder form before the age of 5 but seemed to persist much longer. When improvement occured in this group, it was often in the years from 8 to 12 and sometimes not till 13 to 16 years of age.

There were similar and marked improvements in both the groups on all the other related items of social behaviour. The only differences were on the 2 ratings of eye-contact. Subjects in the Average IQ group, who had tended to avoid eye-contact by looking through others, showed a significant improvement by 5 to 7 years. In the Lower IQ group, by contrast the tendency had been to avoid eye-contact by turning face or whole body away and this seemed to persist after the age of 16.

Such marked differences between the 2 groups as found on the social behaviour items did not occur in relation to the language abnormality or the stereotypies. Although none of the differences reached significance, it was interesting to note that all the language abnormalities except for the reversal of pronouns had been more common in the Average IQ group and seemed to persist after 16 years, even though in a much milder form. The parents who had reported these abnormalities as still continuing had all stated that these only occured sometimes and also that the subject would stop if asked to do so.

The persistence of motor stereotypies and elaborate repetitive routines was marked in both groups. A very high proportion of the Lower IQ subjects still showed some distress if there was a change in the normal routine. Again, the parents had emphasized that the problem was far less severe than before. It was interesting to note that this was one item on which the Average IQ group had shown improvement later than usual , i.e. not until age 8 to 12 years in most cases.

Finally, there was one other important difference between the groups. This concerned the age of onset of the autistic behaviours. In the Average IQ group the autistic behaviours rated were either present by the age of 5 years or never. By contrast, in the Lower IQ group, on various items, there were a few subjects who developed these behaviours later, around the ages of 9 and 10, and then continued to show these behaviours as adults.

3.4.4. Conclusions

The Average IQ group showed a more severe picture of social impairment before the age of 5 , but began showing an improvement in these behaviours soon after the age of 5. They were also less likely to develop any of the autistic behaviours rated after the age of 5. In this sense, they fit the classical picture of autism more closely. The Lower IQ group, on the other hand, showed a less severe but a more persistent picture of social impairment. They were also likely to develop some autistic behaviours after the age of 5. As expected, most of the secondary autistic behaviours such as the language abnormalities and the repetitive routines persisted into adulthood in both groups but in a less severe form than shown in childhood. The implications of these findings are discussed in the general concluding section at the end of this chapter.

3.5 The current state of social impairment

3.5.1. Method

Information about each subject's quality of social interaction at the time of the study had been collected as part of a routine of assembling background information. At this stage, the author had no hypothesis concerning the relationship of IQ to social interaction, so it was unlikely that there was any bias in the ratings of social interaction made as discussed below.

Each subject's quality of social interaction was rated on a modified version of the Wing & Gould scale of social impairment. This scale is contained in the Handicaps, Behaviour and Skills (HBS) Schedule (Wing and Gould, 1978), and its modified, abbreviated version, The Disability Assessment Schedule (DAS). The reliability of the scale for children has been reported by Wing and Gould (1978) and for adults by Holmes, Shah and Wing (1982). The rating was based on observation in various situations and on information collected from staff by using the semi-structured interview method described by the authors of the scale (Wing & Gould, 1978; 1979).

A modification and extension of the scale was necessary. The author found that the types of social interaction shown by many of the subjects at the time of the study did not precisely correspond to any of the categories, aloof, passive ,odd or normal, as described in the DAS. This was probably because the subjects in the present sample were older and more able than the large majority of the original epidemiologically based population of mentally retarded and autistic children for whom the categories were formulated. Two extra categories were added as follows:-

1. Mostly aloof, sometimes passive - This applied to the person who stayed aloof and never interacted except in a structured one to one situation in which they appeared quite amiable and responsive.

2. Sociable but stilted - This was used to describe subjects who were on the whole sociable and communicative. They did initiate social interaction that was appropriate and not odd or one-sided or repetitive. However, their behaviour was very stilted and mechanical and appeared 'unnatural' in subtle ways.

The modified version of the scale as used in the present study is described in Appendix (7).

3.5.2. Results

The numbers of subjects showing each type of social impairment in the two groups are shown in Table 3.13.

The frequencies of the different categories could not be analyzed statistically as there were too few subjects in each cell. It was of interest to compare the proportions in each group who showed the mildest form of social impairment, that is, sociable but stilted. Six out of the 10 of the

TABLE 3.13.
Current quality of social interaction

	Average IQ group (N=10)	Lower IQ group (N=10)
	No. of Ss	No. of Ss
Aloof	0	0
Passive	0	4
Odd	1	2
Aloof & Passive	3	2
Normal but stilted	6	2
Total	10	10

Average IQ Autistic group showed this type of social impairment at the time of the study compared to 2 out of the 10 in the other group. This difference does not reach significance. There were no subjects in either group who were totally aloof. The few who were usually aloof were amenable and responsive in a one to one structured situation, for example during testing.

The ratings made by the parents on the ECQ cannot be compared directly to these ratings for two reasons. The scales used were different and the ratings were mutually exclusive on the scale used at the time of the study but not on the ECQ.

3.5.3. Discussion

These findings generally corroborate the results of the questionnaire study regarding the subjects' quality of social interaction. None of the subjects are now rated as aloof, a characteristic which was present in all except one subject in early childhood. The qualitative ratings of social interaction suggest that the Average IQ group has made even greater strides in this domain. A high proportion are now rated as 'sociable but stilted'. These subjects are thus interested in social interaction and are able to interact with other people without being one-sided or repetitive. One hypothesis to explain this may be that because they are more intelligent, they have learned strategies and skills that are superficially effective in social situations, albeit through a different route to normal social development. Hence, the social impairment is still apparent but in a more subtle form of 'stiltedness'. Such a hypothesis has been put forward by Hermelin and O'Connor (1985) and has been discussed in more detail by the present author elsewhere (Shah and Wing, 1986). The greatest proportion of the Lower IQ group are now 'passive' or 'odd'. These findings corroborate reports of other studies concerning the improvement in social impairment with age (Shah,1986) and also the findings that autistic adolescents and adults of higher intellectual ability have a better prognosis for social behaviour (Rutter, 1970; Lotter,1974a).

It was shown by both the parents' ratings and the ratings made on observation that a large proportion of the Average IQ group cannot be rated on the existing categories of aloof, passive and odd of the Wing & Gould scale of social impairment. The observations of the present study suggest 2 additional categories are necessary. Of these, the category of 'sociable but stilted' may be particularly useful when rating the quality of social interaction in the more able autistic adults and should be incorporated in the scale.

3.6. General discussion and conclusions

The main findings of the present study regarding the clinical and behavioural differences between the Average IQ and Lower IQ group of autistic adults are as follows.

The Average IQ group shows a more severe form of autism before the age of 5. Specifically, they are rated as showing a more severe form of the classic aloofness described by Kanner (1943), more likely to avoid eye-contact by looking through people, more likely to have severe echolalia, repetitive speech, motor stereotypies and elaborate repetitve routines. However, they show marked improvements in autistic behaviours after the age of 5, especially in social interaction and behaviours related to it. As adults, they retain all the main features of autism, that is the social impairment, language abnormalities and elaborate repetitive routines but in a much milder form than shown in childhood.

The Lower IQ group show all the classic autistic features but rarely in a severe form before the age of 5. They do not show much improvement in the early school years. There is improvement on some autistic behaviours in the older childhood and adolescent years, but they are also more likely to develop additional autistic features after the age of 5 and continue showing these as adults.

The findings regarding outcome in the 2 groups are not new and corroborate findings of earlier studies regarding the general tendency for autistic behaviour to improve with age, and the relevance of IQ as a prognostic factor for autistic behaviour in adulthood. However, no previous studies have compared 2 such homogeneous groups of autistic people. The findings regarding the differences between the groups in the severity of the autistic behaviours in early childhood are empirical and cannot be directly compared with any other studies. The question posed by these results is why do autistic people of normal non-verbal IQ show a more severe picture of autism in their early years than autistic people of lower non-verbal IQ.

One possibilty is that these findings are simply due to sampling or referral bias. There may in fact be an equal number of autistic people with normal non-verbal IQ but with a mild form of autism in early childhood. These children may go unnoticed by virtue of their higher intelligence and mildness of their autistic behaviours, and may not need to be referred to any specialist services. Thus, they may not feature in any research studies. On the other hand, autistic people with normal non-verbal functioning but with severe autistic behaviour would be referred for specialist services and are likely to be in schools for autistic children. Autistic children of lower non-verbal IQ would need special services regardless of the severity of their autistic behaviour. It is still difficult to explain the preponderence of mild autism in childhood in the present sample of Lower IQ autistic children. One possiblity is that Lower IQ autistic children with severe autistic behaviour in childhood would appear much more handicapped and may be referred to services for severe mental retardation. These children would be likely to end up in the schools for learning disability rather than the special schools for autistic children.

Another possiblity is that there is a genuine association between a high level of non-verbal functioning and the severity of autistic behaviour in early childhood. The overall non-verbal IQ is a very global measure and may be covering up more subtle differences in cognitive processes betweeen the groups. It may be a particular skill or style of cognitive processing which is responsible for both the high non-verbal IQ and the severity of autistic behaviours.

The remainder of the thesis pursues these questions further by investigating underlying cognitive skills and strategies in these 2 groups of autistic adults. The performance of the 2 groups is compared to each other's and to that of various non-autistic control groups. The next chapter considers in detail what the non-verbal IQ actually consists of in the 2 groups by comparing their performance on the individual subtests of the IQ tests.

3.7. Summary of Chapter (3)

In this chapter, the two autistic groups were compared on major clinical symptoms to see if there were any differences. The Average IQ Autistic group showed more severe autistic symptoms before age 5 but showed marked improvement in these soon after age 5. The Lower IQ Autistic group showed all the autistic symptoms in a less severe form before age 5, and these persisted longer. As adults, both groups retained all the main features of autism but showed them in a milder form than in childhood. The Average IQ Autistic group showed a greater improvement in social behaviour than the Lower IQ Autistic group. Possible reasons for these differences between the two autistic groups were discussed.

CHAPTER FOUR

Sub-test profiles on the WISC-R/WAIS test

4.1. Introduction

The previous chapter raised the question of possible differences in cognitive functioning between the Normal IQ autistic group and the Lower IQ autistic group. This chapter investigates cognitive strengths and weaknesses of the 2 groups by comparing their performance on the WISC-R or WAIS IQ test in detail.

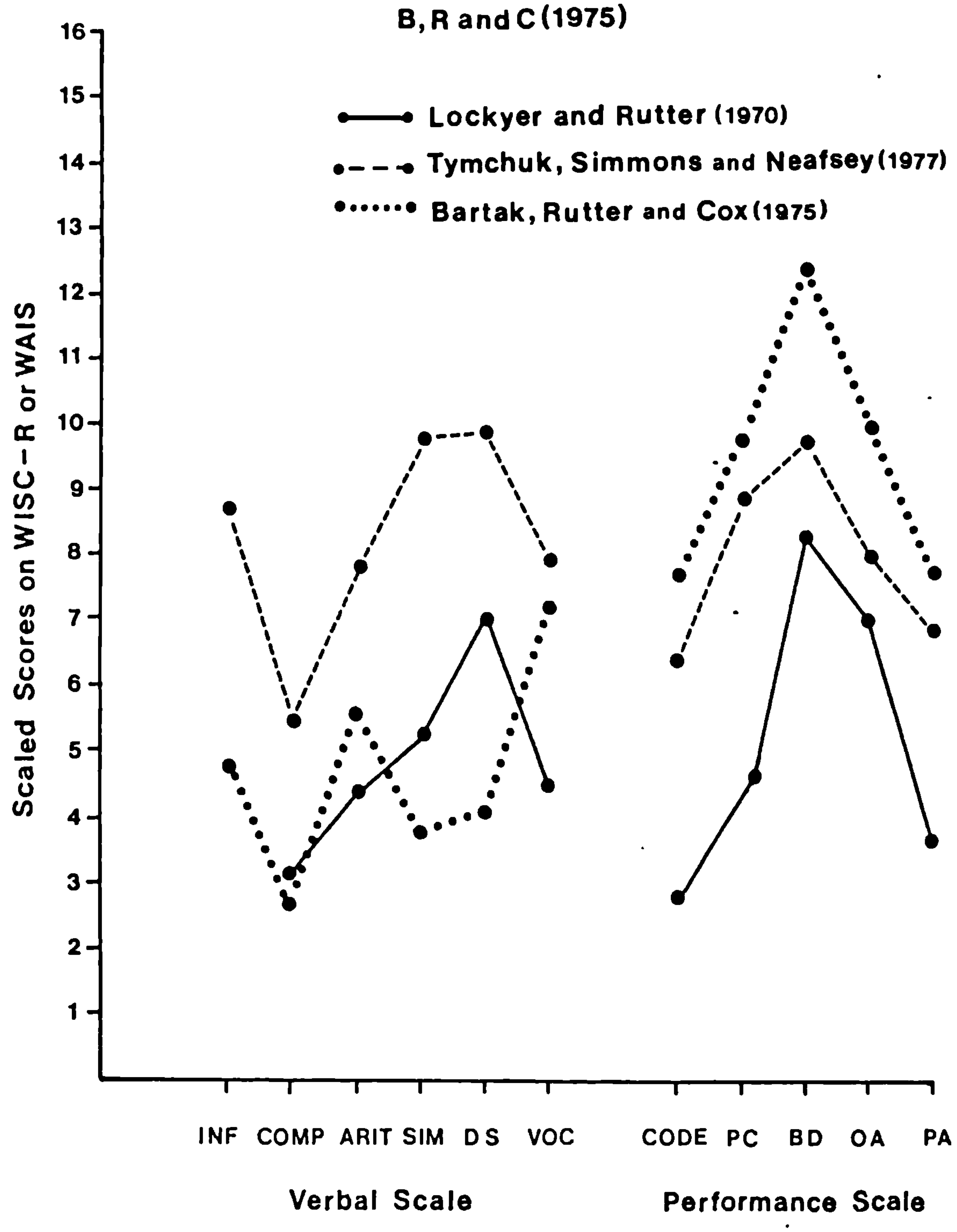
4.1.1. Studies of WISC/WAIS profiles of autistic people: Literature Review

Lockyer and Rutter (1970) investigated WISC or WAIS subtest patterns of 63 children with infantile psychosis and 63 control children attending the same clinic and closely matched for age, sex and intelligence as part of a follow-up study. The verbal and performance IQS were compared for each group. Although a significantly higher number of autistic children had higher performance than verbal IQS, the difference between the Verbal and the Performance IQ was not significantly different in the autistic group (Verbal IQ 77.1, Performance IQ 79.0). For the control group, however, the Verbal IQ was significantly higher than the Performance IQ (Verbal IQ 78.7,Performance IQ 72.2). More interesting differences between the 2 groups concerned the pattern of subtest scores. Figure 4.1 shows the scaled scores of the autistic subjects in this study and other studies discussed below.

While the control group performed uniformly on all

Figure 4.1

WECHSLER SUBTEST PROFILES OF THE AUTISTIC GPOUPS IN THE STUDIES OF L and R (1970) T, S and N (1977) and B, R and C (1975)



subtests, the autistic group performed significantly better on some tests than others. On the verbal scale, their scores on the digit span test were significantly higher than on the scores for comprehension, arithmetic, vocabulary and similarties subtests. The authors do not report scores on the information subtest. On the performance scale, their scores on the block design and object assembly subtests were significantly higher than those for digit symbol, picture arrangement and picture completion.

The psychotic group was then divided according to the children's language usage at follow-up and children with normal or near normal language were compared with those who had a language handicap. The pattern of scores on both scales remained the same for both groups . Both groups still performed best on the digit span test on the verbal scale and on the block design and object assembly tests on the performance scale. However, the scores on these tests were not significantly different from scores on other subtests for the group with normal language. For the retarded language group, object assembly and block design scores were significantly higher than all other performance subtests. The authors conclude on the basis of these findings that

> "the 'islets of ability' defined by these two tests is associated with language retardation in children with infantile autism" (p.159, Lockyer & Rutter,1970).

This conclusion is somewhat contradictory to the actual findings, since the psychotic group without language retardation, too, scored in the normal range only on these 2 subtests of the performance scale. Furthermore, the 'language retardation' on which the conclusion hinges is not defined. The authors do not state the precise criteria on which the groups were subdivided or the measure used to assess language ability. Unfortunately, the groups, after being divided, are not compared on IQ. From the mean subtest scores, it would seem that the retarded language group is also of significantly lower IQ than the group without language retardation. If this is so , then these results can also be interpreted as showing that the block design and the object assembly subtests are the only subtests which are independent of general IQ in autistic children. They score on these tests in the normal range regardless of IQ. Performance on all the other subtests is affected by the level of general retardation. (Block design is the only subtest on which the 2 autistic groups of presumably largely different IQS perform at equivalent levels. The language retarded group performs worse on all other subtests). To take the argument one step further, the groups could have been divided on arithmetic ability. It is highly probable that the same pattern of results would have emerged. It is doubtful whether the conclusion that peaks on block design and object assembly are related to retardation in arithmetic ability would be justified.

Tymchuk, Simmons & Neafsey (1977) compared WISC/WAIS subtest profiles of adolescent autistic subjects of high verbal ability with those of control subjects matched on age, full-scale IQ and sex. The control subjects were a mixed group of normal adolescents and subjects with a diagnosis of mental retardation, learning disability, and behaviour problems. The autistic group (referred to as psychotic by the authors of the study) obtained a significantly higher block design score and a significantly lower comprehension score than the control group. There were no significant differences between subtest means for the control group. All their scores were in the normal range. However, on 3 subtests, i.e. comprehension, coding and picture arrangement, the autistic group had scaled scores below the normal range. These scores were significantly different from most of the other scores. There were no peaks that were very pronounced. Although the mean scaled score for the block design task and the digit span tests were the highest among the tests ,these did not seem to peak significantly over the others. There were various other tests on which the autistic group had scored in the normal range, for example, information, arithmetic, similarities, vocabulary, picture completion and object assembly (see Figure 4.1).

Although the authors maintain that their results agree with those reported by Lockyer and Rutter (1970) , there appear to be more differences than similarities. In particular, the autistic group in the Tymchuk et al's study did not show significant peaks of performance on the block design and object assembly and digit-span subtests as reported by Lockyer and Rutter. Although Tymchuk et al's subjects scored significantly higher on the block design subtest than the control group,it must be remembered that the control group consisted of a high proportion of subjects with a diagnosis of learning disability. There is some evidence that learning disability is associated with poor visuo-spatial skills. These subjects in the control groups then may have found the block design task particularly difficult. The main difference between the two studies was in the selection of autistic subjects. Tymchuk et al's group was of higher overall IQ and all had a high verbal ability. Lockyer & Rutter's group was of lower IQ and of mixed verbal ability. This suggests that the pattern of performance on the IQ tests depends in part on the overall level of intellectual functioning. This is discussed later when findings from all the studies are summarized.

Bartak, Rutter & Cox (1975) have compared the patterns of performance on the WISC of children with a severe developmental language disorder by dividing this group into those with autistic features and those with a 'pure' language disorder without any autistic features. Both groups were matched on non-verbal IQ (mean for autistic group, 96.6; mean for dysphasic group, 90.8). Thus both groups had non-verbal IQ in the normal range and severe receptive language problems. There were various interesting differences between their patterns of performance on the WISC. Both groups had higher performance IQ than verbal IQ but the verbal-performance discrepancy was significantly larger for the autistic group. Thus the groups had similar non-verbal IQ but the dysphasic group had a higher verbal IQ than the autistic group.

On the performance scale of the WISC , the autistic group showed a significant peak on just the block design test (see Figure 4.1). Their performance was at the upper end of the normal range on this test. However, the difference between the means of the 2 groups on the block design test did not reach significance (12.4 for the autistic group compared to 9.9 for the dysphasic group). The dysphasic group did not show such a peak on any one test but performed relatively better on 3 subtests, the block design, object assembly and picture completion. However, their performance on these did not approach the upper end of the normal range.

On the verbal scale, there were more differences between the 2 groups. The autistic group performed significantly worse on comprehension, similarities and the vocabulary subtests compared to the dysphasic group. There was very little subtest variation between the scaled scores for the dysphasic children. These ranged from 5.1 (information) to 6.8 (arithmetic). The autistic group showed a significant peak on the digit span test . This was the only subtest in the verbal scale on which they scored in the normal range. The scaled scores for the autistic group ranged from 2.7 (comprehension) to 7.2 (digit span).

This study provides a model of good research design. Many problems of interpretation of results are avoided by using a homogeneous group of autistic children with respect to non-verbal IQ and language disorder. Moreover, the use of a control group of similar non-verbal IQ and similar language disorder makes it possible to attribute the differences between the groups to the presence of autism per se rather than to general language retardation.

To summarize , the WISC results of autistic children in this study show that on the verbal scale, they tend to score in the normal range on the digit span test and do particularly poorly on the comprehension test. On the performance scale, they tend to perform particularly well on the block design test. None of these findings apply to the control group of dysphasic children. Thus, the conclusion drawn by Lockyer and Rutter that islets of ability in autism are associated with language retardation is questioned once again.

A recent study by Ohta (1987) suggests that these findings regarding peaks of performance on the WISC are applicable to Japanese autistic children. Ohta compared WISC profiles in 16 Japanese autistic children and 16 control children matched on non-verbal IQ on the WISC. The control group consisted of 8 normal children and 8 children with hyperkinetic syndrome. The verbal and full-scale IQs of the control group were significantly higher than those of the autistic group. On the verbal scale, the autistic group had significantly lower scores than the control group except on the information subtest on which there was no difference. On the performance scale, the autistic group scored higher than the control group on the block design and object assembly tests but this difference was not significant. The only significant difference was on the picture arrangement subtest on which the autistic group scored lower than the control group.

The intra-test scatter of the autistic group was of interest and in keeping with the general trend reported in the studies above. On the verbal scale, the scaled scores on all the subtests were below normal. The lowest score (1.4) was on the comprehension subtest, and the highest score (6.1) was on the digit span subtest. The authors do not report any statistical tests on these intra-test differences. On the performance scale, the autistic group scored in the normal range on the block design and object assembly subtests, and interestingly also on the mazes test (an optional test which is not usually carried out). Again, it is not known whether the differences between these scores and those on the remaining tests are significant.

Asarnow, Tanguay, Bott and Freeman (1987) compared the performance of non-retarded autistic children with schizophrenic children. This study used factor scores rather than individual subtest scores to describe the pattern of performance. The main findings regarding factor scores were that the scores of the autistic children were significantly higher on the perceptual-organization factor than the scores of schizophrenic children. Within-group analysis showed that the autistic children had significantly higher scores on the perceptual- organization factor than on the verbal comprehension factor and the distractibility factor.

The validity of this method is questionable as the factor structure may not be the same for the abnormal groups as it is for the general population. The scores on individual subtests are far more informative. The autistic group scored in the superior range (mean scaled score=14) on the block design test, and scored below average on the comprehension subtest (mean scaled score=5). The authors also report results for subgroups of the autistic group. The autistic group was subdivided into those currently meeting the DSM 111 criteria of a diagnosis of autism (autistic current group) and those who had previously met the criteria but currently showed improvement in their language functioning and social relatedness (autistic residual group). The autistic residual group obtained significantly higher scores on the verbal factor and the distractibility factor compared to those obtained by the autistic current group. In particular, the autistic residual group obtained significantly higher scores on the comprehension subtest. It is noteworthy that these differences between the two groups did not apply to the perceptual organization factor and particularly to the block design test. There is no discussion of the differences in overall level of intelligence between the groups. In view of the established relationship between prognosis of autistic features and level of intelligence, it seems very likely that the autistic residual group was of higher overall IQ than the autistic current group. If this is so, then these results provide more evidence of the superior performance on the block design task by autistic groups differing in overall IQ levels. This suggests that their performance on the block design task at least is independent of overall IQ. This possibility is discussed further in the concluding section.

Wolff & Barlow (1979), in their study of schizoid children, have reported WISC test results of autistic children of high overall IQ (full scale, 89.5; verbal,89.4; performance, 93.5). In this study, the differences between subtest means were not significant for any of the 3 groups, autistic, schizoid and normal. On the verbal scale, the autistic group scored below average on the comprehension subtest (mean scaled score=5.7) and in the normal range on all the other subtests (range= 7.88 to 9.5). However these differences were not very large and in fact not significant. On the performance scale, the highest score was on the block design test (mean scaled score=10.6), but this did not peak over the other scores which too were in the normal range (range =7.13 to 10.0).

The studies described above include all studies (to date) that have analyzed the WISC/WAIS profile of autistic children in any detail. Two studies often quoted in the literature on the subject have been deliberately omitted. These include a study by Gillies (1965) which gives a misleading picture as the autistic subjects in the study did not cooperate on some of the tests of the WISC, and a study by Wassing (1965) which included only 4 subjects and very limited statistical analysis. It is curious that other authors (e.g. Lockyer & Rutter, 1970; Tymchuk et al, 1977) who have quoted these studies have not commented on these methodological shortcomings which render the results totally uninterpretable. Gillies (1965), especially has made very clear in the paper that the psychotic subjects in the study

> "performed in such a way as to make failure and lack of co-operation indistinguishable" (Gillies,1965, P.99).

4.1.2. Conclusions

The studies reviewed above show unanimously that the autistic children seem to perform differently on the Wechsler Scales from control groups of non-autistic children. In general, autistic subjects tend to show a lot of inter-test variability whereas control subjects perform more uniformly on the different subtests. There are certain findings which are replicated by most studies regarding the pattern of performance on the tests by autistic subjects. It is thus tempting to draw neat conclusions about the autistic subject's 'typical' test profile on the Wechsler Scales. However, there are also important differences between findings of the different studies. Below is a summary of the outstanding features of the autistic subject's performance on the WISC/WAIS and a discussion of the qualifications that need to be made to each.

1. <u>Significant discrepancy between overall verbal and performance IQ</u>

The evidence for this is very mixed. The only conclusion that can be justifiably drawn is that although many autistic people show a significant discrepancy between the overall verbal and performance IQ, this is not true of all autistic people. Many of the studies have reported no differences between their overall verbal and performance IQs. Autistic children of low IQ and limited language often fail to score at all on the verbal tests and thus are regarded as obtaining a higher performance IQ . However, they may have failed to understand test requirements on the verbal subtests. The discrepancy between their performance and verbal IQ does exist but this discrepancy cannot be compared to the discrepancy in IQ obtained by subjects who have obtained some scores on both the verbal and performance scales. Autistic subjects of higher intelligence and good language ability have been reported as having similar verbal and performance IQs. However, in some studies, such autistic subjects have been reported to have a significantly higher verbal IQ.

There does not seem much to be gained from discussing verbal-performance IQ discrepancies for this group which shows great inter-test scatter within each scale. Nevertheless, there is the possibility of various subgroups of autistic people with respectively high verbal or performance IQ. It may be worthwhile for future studies of intellectual profiles of autistic children to use the presence or absence of a verbal-performance discrepancy and the direction of the discrepancy as a criterion for subdividing autistic groups as it may be reflecting more underlying cognitive differences.

2. Peak performance on the digit-span subtest

In most studies, there is a tendency for the autistic group to score relatively highly on this. However, only a few studies have reported the autistic group's performance on this test as being significantly different from the other verbal subtests. Thus, whether the performance on this test constitutes a peak of performance depends on the overall IQ level and hence scores on the other verbal subtests. In autistic subjects of low overall IQ and low verbal ability, the digit span score is significantly higher than the scores on the other verbal subtests but it is still rarely in the normal range. Thus, the peak is not an 'islet' of normal functioning. The level of performance on the digit-span test is not independent of the overall IQ. In autistic children of normal or above normal overall IQ, the score on the digit-span is usually in the average range but it is not always significantly different from the scores on other verbal subtests. Thus, although the digit span is a test that most autistic subjects do relatively well on, not all autistic subjects show a significant peak on this test, and not all of them perform in the normal range on this test.

3. Peak performance on the block-design subtest

All the studies reviewed have consistently reported a high level of performance on the block design task. The level of performance, without exception, has been reported to be at least in the average range. In many studies, it is the only test on the performance scale on which the autistic group have scored in the normal range. This is a remarkable finding in view of the largely differing IQ levels of the autistic groups in the different studies. Their apparently 'normal' level of functioning on the block design task is thus independent of overall IQ level. It should be recalled that this was not true of their performance on the digit-span subtest. The assertion by certain authors (e.g. Lockyer & Rutter, 1970) that this islet of normal functioning on the block design test is associated specifically with language retardation is not justified. It should be noted in this context that the non-autistic dysphasic children in Bartak et al's study did not show this significant peak of performance on the block design task.

There are mixed reports as to whether the scores on the block design task peak significantly over the other tests. This seems to depend on overall IQ level, and thus the scores on the remainder of the tests. It appears certain that <u>all</u> autistic children, who have sufficient level of cognitive ability to be tested on the Wechsler Scales, are able to score on the block design task in the average range at least. For autistic subjects of below normal IQ, this represents a significant peak as the scores on the other performance subtests are usually below normal , in keeping with the overall intellectual level. For autistic subjects of normal and above normal IQ, the score on the block design does not represent such a significant peak because they are likely to score in the normal range on some other tests as well, in keeping with their high overall level of intelligence.

All the studies have used control groups of children matched on non-verbal IQ, and have reported the autistic group's performance on the block design task to be significantly higher than that of the control group. The studies have used different types of control subjects and often subjects with mixed diagnosis. The comparison between the autistic subjects is thus with another developmentally delayed group. These findings must be interpreted with some caution as the autistic group may appear to do particulary well in comparison with another group in which some subjects may have particular difficulty with the block design task. The autistic group's performance is thus not being compared to normal performance, but to that of another group who may have a different uneven profile on the subtests.

Thus, to conclude, all autistic children, who are testable on the Wechsler Scales, show at least normal functioning on the block design task. Whether this is an islet of normal functioning depends on the overall IQ level and the level of performance on the other subtests.

4. Peak on the Object Assembly Test

Findings regarding peak performance on the object assembly test are not as clear cut as on the block design test . Although there is a tendency for the autistic group in most studies to do relatively well on the object assembly test, their performance on this test is usually not significantly different from other performance subtests. In a few studies, the scores on the object assembly test have been reported to be as high as those on the block design test. However, autistic subjects of all IQ levels do not always attain scores in the normal range on the object assembly test as was the case for the block design test. The scores on the object assembly test are more in keeping with the overall IQ level of the subjects, and thus are liable to drop below normal if overall non-verbal IQ is below normal. For the normal population, performance on the object assembly and block design tests is explained by a single factor which has been described as perceptual organization and space-performance ability (Cohen,1959). The review of the findings regarding the autistic subjects' performance on the 2 tests suggests that the factor structure may not be the same for autistic subjects.

5. Low level of performance on the comprehension subtest

Findings regarding this are somewhat mixed. Although none of the studies report a particularly high score on this test, most studies do not single out the autistic group's performance. In many studies, the scores on this test are not significantly different from scores on vocabulary, similarities and arithmetic subtests. Of particular relevance is the study by Bartak et al. (1975) which compared performance of autistic children with dysphasic children. Although the autistic group in their study performed significantly worse on the comprehension test, it is important to note that they performed significantly worse on other verbal subtests as well, i.e. similarities and vocabulary. Thus, when low scores are reported for the comprehension subtest, they need to be compared with scores on other verbal subtests. Low scores on all verbal tests may be reflecting a more general problem such as communicative competence. The pattern of performance on the verbal subtests is of particular interest for autistic subjects with high verbal skills. If they show a particular deficit, for example on the comprehension subtest, it may reflect specific cognitive or communication problems rather than low general verbal ability. Unfortunately, findings of studies of autistic subjects with high verbal skills do not consistently show a significantly low score on the comprehension subtest.

The mixed nature of findings regarding the autistic subjects' performance on this subtest once again suggests that there may be different subgroups of autistic subjects who show certain specific deficits.

4.1.3. Overall Conclusion

The picture regarding the IQ test profiles turns out to be quite complex when the findings from the different studies are brought together. However, one remarkably consistent finding that emerges in all studies is that concerning the high level of performance on the block design subtest regardless of the IQ level of the subjects. Performance on all other subtests seems to be associated with the general cognitive level which makes it difficult to separate the effects of specific cognitive deficits from general deficits. The discussion above highlights the possibility of several subgroups within the autistic population.

However, it must not be overlooked that performance on the WISC or WAIS is only partially determined by underlying abilities. Other factors such as teaching, experience, and communicative competence play a role too. Clarke & Clarke (1973) have discussed the limited explanatory powers of general scores such as MA in mental retardation research. Hypotheses regarding specific cognitive deficits which are based solely on IQ test performance are not always confirmed by experimental studies. For example, the often cited finding by Rutter (1978) of a cognitive deficit of "coding and sequencing" in autism is derived from performance on the digit symbol and picture arrangement subtests of the Wechsler scales. However, Baron-Cohen (1986) found that it was not the sequencing element of the picture arrangement task that the autistic children found difficult, but other factors related to the social context of the pictures. Similarly, the low scores obtained by autistic children on the digit symbol test may not be a reflection of a coding deficit but a tendency to trade accuracy for speed as they try and copy the symbols meticulously to the final detail.

Thus, profile analysis based on standardized IQ tests is of limited value regarding underlying cognitive function. Results of IQ tests aid in putting forward hypotheses about cognitive functioning which need to be investigated by experimental methods. This is the approach taken in the present thesis in the investigation of islets of abilities.

Before embarking on experiments investigating more specific aspects of cognitive functioning of the 2 autistic sub-groups taking part in the present study, it seemed pertinent, especially in view of the inconsistencies reported above, to establish how the two groups fared on the Wechsler tests, and how their performance on these compared with findings discussed above. The previous chapter established various clinical differences in these 2 subgroups. The next section investigates whether these differences extend to profiles of performance on the Wechsler IQ tests.

4.2. Aims of the present study

The overall aim of the present study is to compare IQ test profiles of 2 groups of autistic subjects differing in the level of overall non-verbal intelligence, and past and present clinical behaviour. The performance of each autistic group will also be compared with one or more control groups . The findings will be discussed in relation to previous studies reviewed earlier. The following hypotheses arising from the review of the previous studies are specifically tested for each group:

1. Is there a significant discrepancy between verbal and performance IQ?
2. Is there significant inter-test scatter within each scale?
3. Are there significant peaks of performance on the digit-span, block design and object assembly subtests?
4. Is the performance on the block design test at least in the normal range, regardless of the IQ level of the subjects?
5. Is the performance on the comprehension subtest significantly lower than the performance on other verbal subtests?

4.3. Method

4.3.1. Subjects

All 5 groups of subjects described in Chapter 2 participated in this study. These were as follows:

Group 1 (Average IQ Autistic) - 10 autistic subjects with non-verbal IQs between 86 and 108.

Group 2 (Lower IQ Autistic) -10 autistic subjects with non-verbal IQs between 57 and 81.

Group 3 (Older Normal) - 17 adolescents of normal IQ.

Group 4 (Younger Normal) - 16 children of normal IQ.

Group 5 (Lower IQ Non-Autistic) - 12 non-autistic subjects with non-verbal IQ in the mildly retarded or borderline range.

Detailed descriptions of the groups and the matching criteria is given in Chapter 2. Tables 2.1 and 2.2 give group means for age and IQ.

4.3.2. Procedure

Each subject in groups 1, 2 and 5 was tested individually on the full WISC-R or WAIS (depending on the age of the subject) at the beginning of the study by the author. Appendices(8) - (12) indicate which test was used for each subject. The tests were administered according to the instructions in the manuals (Wechsler,1955; Wechsler, 1974). The 2 normal groups were not assessed fully on the WISC-R or WAIS as they can be assumed to function in the average range. However, they were assessed on the performance scale of the WISC-R or WAIS to confirm this.

4.4. Results

The raw scores for each subject were converted into age-scaled scores using the tables given in the manuals.

Sub-test scores reported from now on refer to age-scaled scores on either test. There is evidence that these are comparable for normal and psychotic populations (Wechsler,1974; Lockyer,1967). The scaled scores for individual subjects are given in Appendices (8), (9), (10), (11) and (12).

Two types of analysis were done. The first was to examine differences within each group. The second was to determine if there were any significant differences between any of the comparison groups on the relevant subtests.

A note on the statistical analysis

The statistical analysis used in all previous studies of subtest patterns on IQ tests of autistic subjects needs comment. Most studies (e.g. Lockyer & Rutter,1970; Bartak, Rutter & Cox, 1975) have used the post-hoc Tukey or Newman-Keul test to test for a significant gap between subtest scores arranged in a hierarchical order. This is not a suitable procedure for this type of repeated measures data and was not recommended by 2 independent statisticians consulted by the author. Other authors (e.g. Tymchuk et al,1977) have carried out more appropriate analysis using paired t-tests but have failed to quote significance levels. In the present analysis, specific hypotheses are tested out by analysis of variance for repeated measures and one-tailed paired-associate t-tests. Wherever a number of t-tests are used, the result is taken as significant only if the probability level is less than 1%.

4.4.1. Within-group subtest profiles

Table 4.1 gives the means and standard deviations for the full-scale IQ, performance IQ, verbal IQ and for the scaled scores of each subtest for all 5 groups. These are plotted in Figure 4.2.

The hypotheses listed above were tested for each group separately.

4.4.1.1. Verbal-Performance Discrepancy

The performance IQ was significantly higher than the verbal IQ for the Average IQ Autistic group (t=.466;df=8;p<.01), and for the Lower IQ Autistic group (t=7.45;df=8;p<.001). There was no significant difference for the Lower IQ Non-Autistic group (t=.054;df=10;NS).

Sub-test scatter - Verbal Scale

To see if subtest means were significantly different, a one-way ANOVA for repeated measures was carried out for each group.

For the Average IQ Autistic group, there was a significant difference between subtest means on the verbal scale (F5,40=6.08; p<.01). To test the specific hypotheses regarding peak performance on the digit-span test and a trough on the comprehension test, the mean of each of these tests was compared to the overall mean of the remaining 4 verbal subtests, i.e. information, arithmetic, similarities and vocabulary. The mean score of the comprehension subtest was significantly lower than the mean of theother verbal subtests (t=3.29,df=8;p<.01). However, the mean digit-span score was not significantly higher (t=1.79,df=8,NS). Examination of the mean scores (Table 4.1) shows that the scaled scores for this group were below average on all the verbal subtests, including digit-span, and were particularly low on comprehension.

TABLE 4.1.
IQ-test scores for the 5 groups

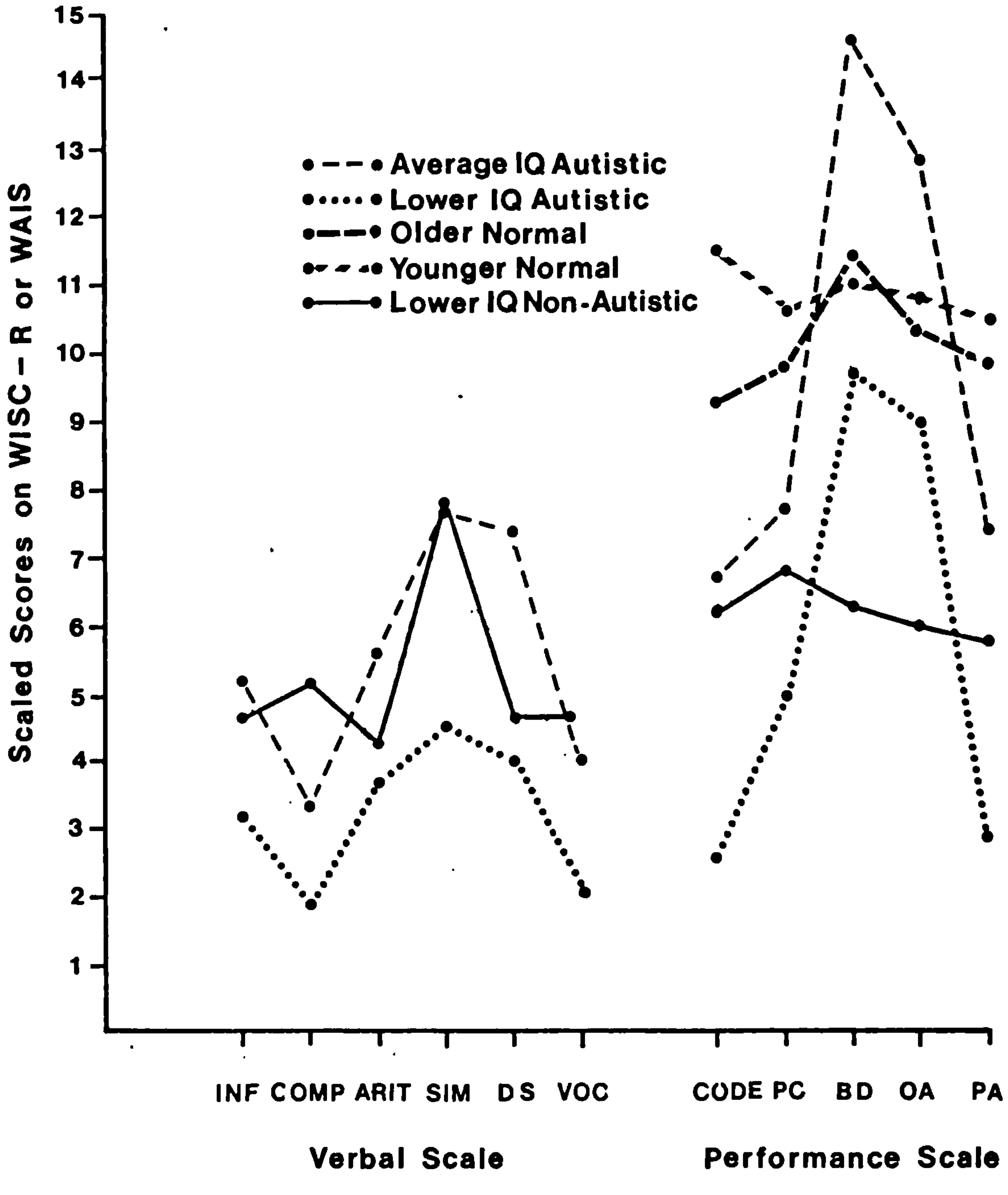
	Average IQ Autistic			Lower IQ Autistic		
	N	mean	(sd)	N	mean	(sd)
FIQ	9	83.3	(11.0)	9	62.0	(7.4)
VIQ	9	73.3	(15.8)	9	56.9	(8.5)
PIQ	9	97.7	(8.3)	9	72.6	(4.9)
INF	9	5.2	(3.5)	9	3.2	(2.6)
COMP	9	3.3	(1.9)	9	1.9	(2.0)
ARITH	9	5.6	(3.9)	9	3.7	(2.2)
SIMIL	9	7.6	(3.6)	9	4.6	(2.5)
DIGIT	9	7.4	(3.1)	9	4.0	(2.5)
VOCAB	9	4.0	(3.0)	9	2.0	(3.0)
COD	9	6.7	(1.8)	9	2.6	(1.9)
PCOMP	9	7.7	(2.5)	9	5.0	(2.3)
BLOCK	10	14.6	(2.8)	10	9.7	(2.4)
OBJECT	10	12.8	(2.3)	10	9.0	(1.8)
PA	9	7.4	(4.3)	10	2.9	(2.2)

	Older Normal			Younger Normal			Lower IQ Non-Autistic		
	N	mean	(sd)	N	mean	(sd)	N	mean	(sd)
FIQ	-			-			11	73.7	(5.9)
VIQ	-			-			11	74.5	(8.0)
PIQ	16	100.6	(7.1)	16	105.6	(5.5)	12	76.3	(5.5)
INF	-			-			11	4.7	(2.7)
COMP	-			-			11	5.2	(1.1)
ARITH	-			-			11	4.3	(0.8)
SIMIL	-			-			11	7.8	(1.3)
DIGIT	-			-			11	4.7	(2.3)
VOCAB	-			-			11	4.7	(2.0)
COD	16	9.3	(3.1)	16	11.5	(1.6)	12	6.2	(0.8)
PCOMP	16	9.8	(2.2)	16	10.6	(1.7)	12	6.8	(1.5)
BLOCK	17	11.4	(2.0)	16	11.0	(1.5)	12	6.3	(1.9)
OBJECT	17	10.3	(1.6)	16	10.8	(1.8)	12	6.0	(0.5)
PA	16	9.9	(1.5)	16	10.5	(1.5)	12	5.8	(0.7)

Figure 4.2

WECHSLER SUBTEST PROFILES FOR THE 2 AUTISTIC

AND 3 CONTROL GROUPS



For the Lower IQ Autistic group, the difference between the subtest means on the verbal scale was not significant ($F_{5,40}=2.22$, NS). This implies that their performance on the comprehension or the digit-span test was not significantly different from the other tests. No further analysis was required. As shown in Table 4.1, the mean scores for all the verbal tests for this group were below average.

For the Lower IQ Non-Autistic group, there was a significant difference between the subtest means on the verbal scale ($F_{5,50}=6.98$; $p<.001$). It was clear from the mean scores shown in Table 4.1 that this was due to a significant peak on the similarities subtest. This was the only test on which this group scored in the average range. The mean scores on the other verbal subtests were almost identical and all below average.

Subtest Scatter - Performance Scale

For the Average IQ autistic group, there was a significant subtest scatter on the performance scale ($F_{4,32}=13.62$; $p<.001$). The specific hypothesis regarding peak performance on the block design and object assembly subtests was examined by comparing the mean scores of these 2 tests with each other and with the remaining 3 tests, i.e. picture completion, picture arrangement and coding. The mean object assembly and block design scores were not different from each other but the mean of these was significantly higher than the mean of the other performance tests ($t=5.07$; $df=8$; $p<.001$). The mean scores given in Table 4.1 show that the performance of this group on the block design and object assembly subtests is above average while that on the remaining tests is average (picture completion) or just below average (coding and picture arrangement).

For the Lower IQ Autistic group, there is a significant difference between the subtest means of the performance scale. Again, this is accounted for by the peaks on the block design and object assembly subtests which are significantly higher than the mean score of the remaining 3 performance subtests ($t=7.33; df=8; p<.001$). For this group, the mean scores on the block design and object assembly subtests are in the average range while the remaining scores are all below average (Table 4.1).

For the Lower IQ Non-Autistic group, the difference between subtest means of the performance scale was not significant ($F_{4,44}=0.82$; NS). The mean scores (Table 4.1) show the even-ness of the scores on the different subtests, all of which are below average.

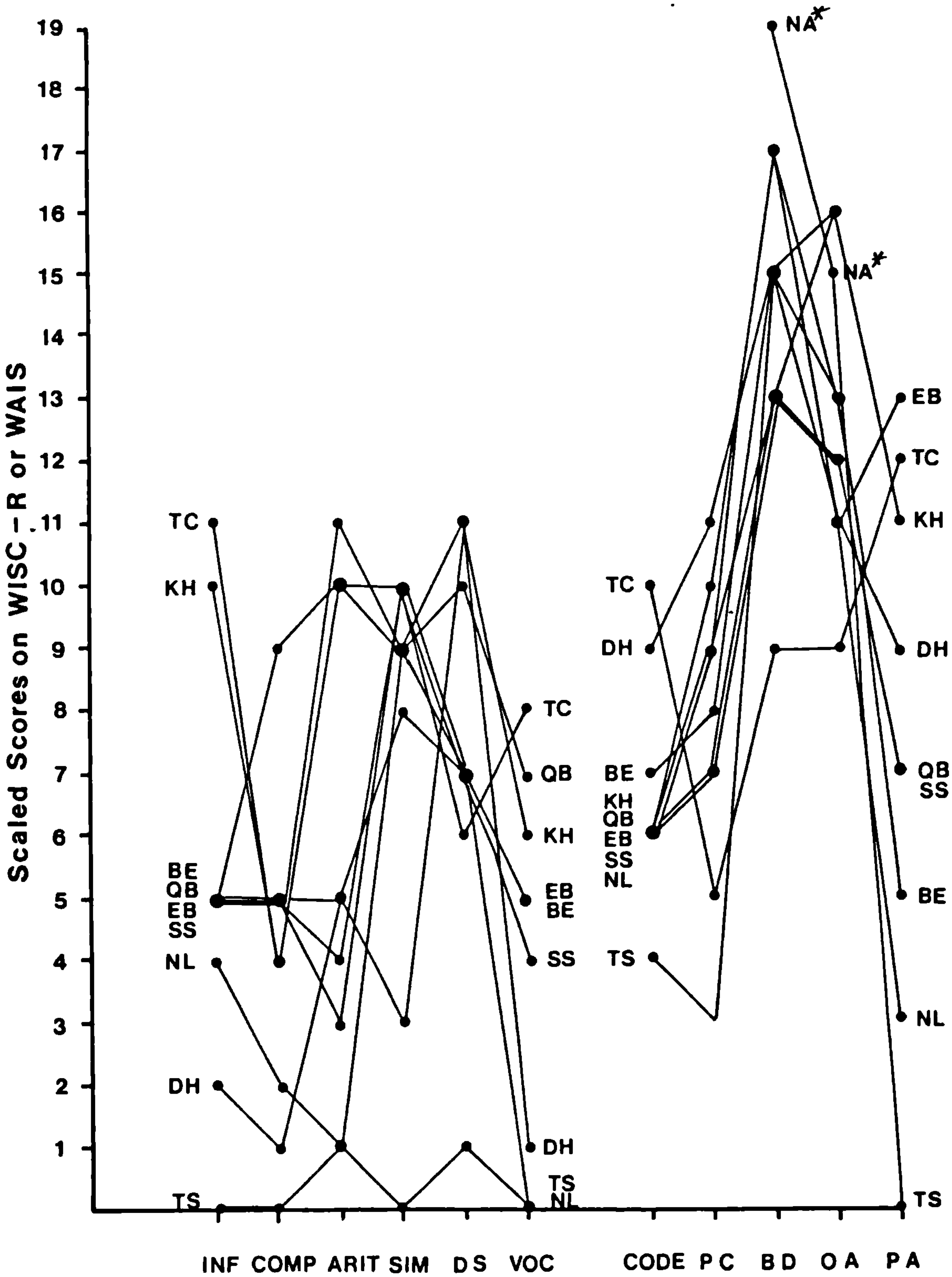
The results of the 2 normal groups for the performance scale are given in Table 4.1, and plotted in Figure 4.2. A one-way ANOVA for repeated measures was carried out for each group to confirm that there was no subtest scatter. There was no significant effect of subtest for the Older Normal group ($F_{4,60}=2.34$; NS), or for the Younger Normal group ($F_{4,60}=0.98$; NS). As can be seen in Table 4.1, the mean scores for both groups for all tests are very much in the average range.

4.4.2 Individual subject profiles for the 2 autistic groups

Individual profiles were plotted for each subject in the Average IQ Autistic group (Figure 4.3) and in the Lower IQ group (Figure 4.4). It is interesting to compare these

Figure 4.3

WECHSLER SUBTEST PROFILES OF INDIVIDUAL SUBJECTS AVERAGE IQ AUTISTIC GROUP (N=10)*

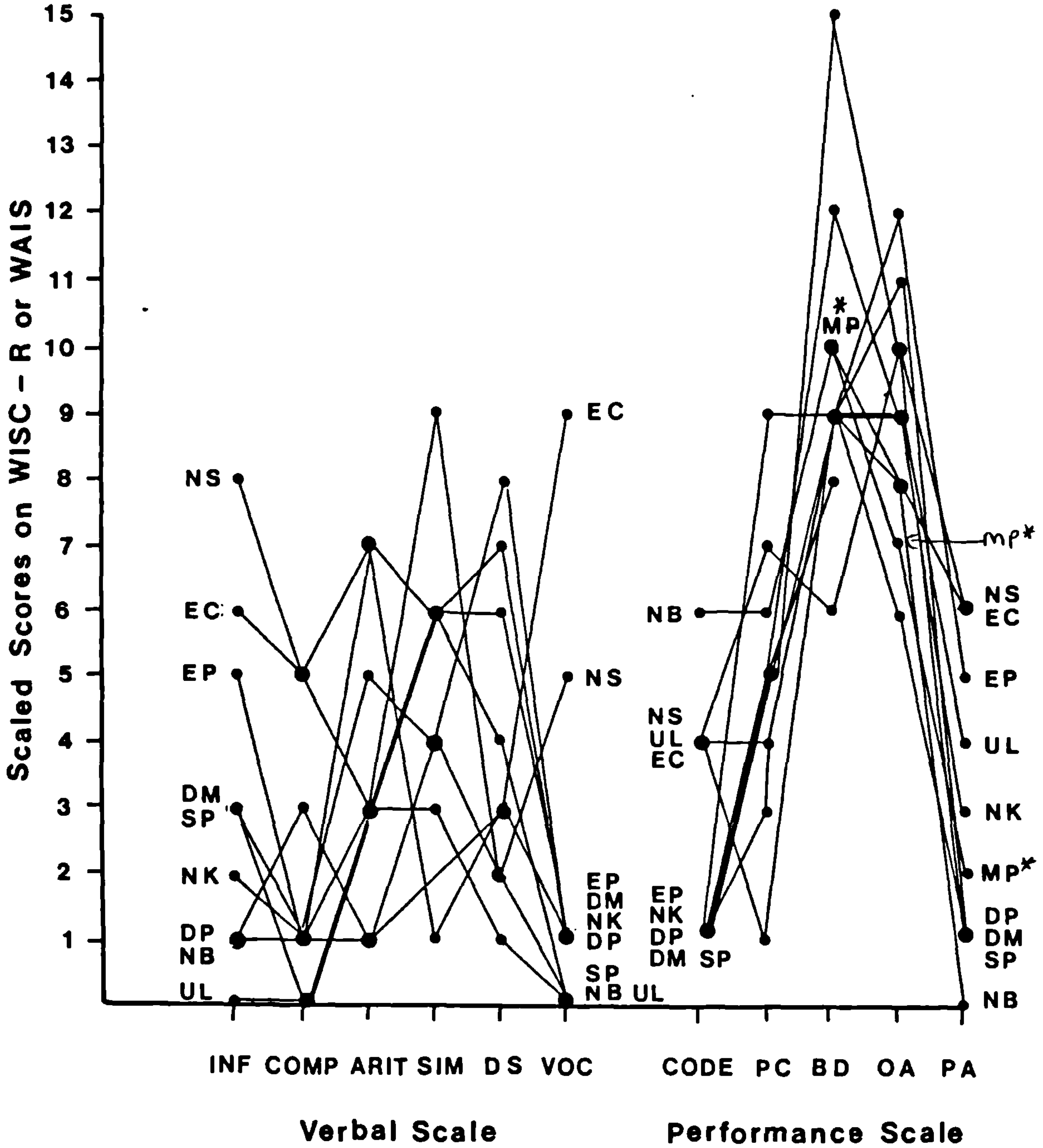


* For subject NA, only scores on two subtests (BD and OA) have been plotted as this subject did not comprehend task requirements for the other subtests. (see Appendix 1A)

Figure 4.4

WECHSLER SUBTEST PROFILES OF INDIVIDUAL SUBJECTS:

LOWER IQ AUTISTIC GROUP (N=10)*



* For subject MP, only scores on 3 subtests (BD, OA and PA) have been plotted as this subject could not understand task requirements for the other subtests. (See Appendix 1B)

with the group profiles plotted in Figure 4.2. For the Average IQ group, the individual profiles on the performance scale are strikingly similar to each other and to the group profile. All except one subject show the characteristic peak on the block design and object assembly tests. The subject (SC) who does not score in the superior range on these tests is the only subject in this group whose verbal and performance IQs are very similar. The individual profiles on the verbal scale are not so strikingly similar but the trough on the comprehension subtest is evident on all but 2 of the subjects.

For the Lower IQ group, the performance scale profiles are again very similar to each other. There is a consistent peak on the block design test but this does not always occur with a similar peak on the object assembly test. The individual profiles on the verbal scale for this group do not conform to any obvious pattern.

4.4.3. Inter-group differences

All inter-group differences were tested by between-group t-tests for each test for each relevant pair of groups. Table 4.1 gives the means and standard deviations for each subtest for each group. The results of the analysis are given in Tables 4.2, 4.3, 4.4 and 4.5. These are summarized below for each pair of groups.

a) Average IQ Autistic vs Lower IQ Autistic
(see Table 4.2)

These 2 groups had been selected according to their performance IQ being at different levels. Hence, it was not surprising that there was a significant difference between

TABLE 4.2.
Inter-group comparison of IQ-test scores:
Average IQ Autistic versus Lower IQ Autistic

	t	P (<)	df**
Full-scale IQ	4.83	.001*	16
Verbal IQ	2.74	.01*	16
Non-Verbal IQ	7.80	.001*	16
VERBAL SUBTESTS			
Information	1.38	ns	16
Comprehension	1.60	ns	16
Arithmetic	1.27	ns	16
Similarities	2.08	ns (.05)	16
Digit-Span	2.62	ns (.02)	16
Vocabulary	1.40	ns	16
PERFORMANCE SUBTESTS			
Coding/digit symbol	4.65	.001*	16
Picture completion	2.36	ns (.05)	16
Block Design	4.20	.001*	18
Object Assembly	4.09	.001*	18
Picture Arrangement	2.93	.01*	17

*Average IQ Autistic group had significantly higher scores on these tests with $p<.01$ or less.

** The different degrees of freedom (ranging from 16 to 18) are due to missing data for one subject in each group on most of the subtests. See Table 4.1 for details of relevant numbers of subjects for each subtest for each group.

TABLE 4.3.
Inter-group comparison of IQ-test scores:
Lower IQ Autistic versus Lower IQ Non-Autistic

	t	P (<)	df***
Full-scale IQ	3.97	.001**	18
Verbal IQ	4.73	.001**	18
Non-Verbal IQ	1.63	NS	19
VERBAL SUBTESTS			
Information	1.26	NS	18
Comprehension	4.77	.001**	18
Arithmetic	0.84	NS	18
Similarities	3.79	.001**	18
Digit-Span	0.65	NS	18
Vocabulary	2.41	NS	18
Coding/digit symbol	5.96	.001**	19
Picture completion	2.24	NS	19
Block Design	3.75	.001*	20
Object Assembly	4.05	.001*	20
Picture Arrangement	2.9	.01**	20

* Lower IQ Autistic group had significantly higher scores on these tests with p<.01 or less.

** Lower IQ Non-Autistic group had significantly higher scores on these tests with p<.01 or less.

*** For details of number of subjects used in the calculation of df, see Table 4.1.

TABLE 4.4.
Inter-group comparison of IQ-test scores:
Average IQ Autistic versus Older Normal group

	t	P (<)	df**
Non-Verbal IQ	0.94	ns	23
NON-VERBAL SUBTESTS			
Coding/digit symbol	2.29	ns	23
Picture completion	2.23	ns	23
Block Design	3.54	.01*	25
Object Assembly	3.33	.01*	25
Picture Arrangement	2.07	.ns	23

*Average IQ Autistic group had significantly higher scores on these tests with p<.01.

** For details of numbers of subjects used in calculation of the degrees of freedom (ranging from 23 to 25), see Table 4.1.

TABLE 4.5.
Inter-group comparison of IQ-test scores:
Lower IQ Autistic versus Younger Normal group

	t	P (<)	df**
Non-Verbal IQ	15.02	.001*	23
NON-VERBAL SUBTESTS			
Coding/digit symbol	12.29	.001*	23
Picture completion	6.99	.001*	23
Block Design	1.68	ns	24
Object Assembly	2.42	ns	24
Picture Arrangement	10.53	.001*	24

* Younger Normal group had significantly higher scores on these tests with p<.01 or less.

** For details of the number of subjects used in the calculation of df, see Table 4.1.

the groups on the performance IQ.

However, it was interesting that although the difference on verbal IQ was significant, there were no differences on any of the verbal subtests at the 1% level. The Average IQ group had significantly higher scores on all the performance subtests, except picture completion. The higher verbal IQ of the Average IQ group was accounted for by the higher scores on the Digit span and similarities subtests.

b) Lower IQ Autistic vs Lower IQ Non-Autistic (Table 4.3)

These 2 groups had been matched on performance IQ. Thus, the interesting comparison was on the performance subtests. There were significant differences but not always in the same direction. The Autistic group scored significantly higher on the block design and object assembly subtest and significantly lower on coding and picture arrangement. The Non-Autistic group had a significantly higher verbal IQ and significantly higher mean scores on comprehension, and similarities subtests. There were no significant differences between the groups on information, arithmetic, digit-span, vocabulary and picture completion subtests.

c) Average IQ autistic vs Older Normal (Table 4.4)

Although the test norms provide an adequate comparison of the autistic group with a normal group, it was interesting to compare the autistic groups with the present normal groups on the performance scale as these results were available for the normal groups. The Average IQ Autistic group and the Older Normal group were matched on non-verbal mental age as well as non-verbal IQ. The results confirmed the uneven profile of the autistic group's scores with significant peaks on the object assembly and block design subtests. The autistic group scored significantly higher on these 2 tests and significantly lower on picture arrangement and coding subtests compared to the normal group. There was no significant difference on the picture completion subtest.

d) Lower IQ Autistic Young Normal (Table 4.5)

These 2 groups were matched only on non-verbal mental age. The normal group had a significantly higher performance IQ. Thus, their tendency to score significantly higher on most of the performance subtests was not surprising. The interesting finding was the lack of difference between the groups on the block design subtest which again confirms the existence of a significant peak on this test in the autistic group.

4.5. Discussion

The present findings confirm the previous general finding that autistic subjects do not perform evenly over different subtests of the WISC or the WAIS.

Both groups had significantly higher performance IQ than verbal IQ. As discussed above, this is not always the case with autistic people. The fact that both groups here show a higher performance IQ, although having significantly different verbal IQs.

This suggests that the differences found between the verbal and performance IQs cannot be attributed to one group having superior verbal skills.

On the verbal scale, although the means of the 2 groups were not significantly different on any single subtest at the 1% level, the inter-test scatter was significant for the Average group but not for the Lower IQ group. The scatter in the Average IQ group was accounted for by the fact that their score on the comprehension subtest was significantly lower than their scores on the other verbal subtests. This suggests that at least for a sub-group of autistic people, i.e. those with average non-verbal IQ, the comprehension test causes particular difficulty which is not due to a general difficulty with verbal tasks. The comprehension subtest requires much more than just verbal skill. The questions about everyday problems , many of which include social circumstances, require the subject to work out the appropriate context for the question and give a common-sense answer. The present findings suggest that the Average IQ Autistic group has particular problems with this. As will be recalled from Chapter 3, this was the group which showed a more severe form of Kanner's classic autism in early childhood. It may be that the Average IQ group in fact retains the very 'pure' autistic problems such as difficulty in interpreting the questions on the comprehension subtest. In the Lower IQ Autistic group, the score on the comprehension test was the lowest but was not significantly lower than the scores on Information, Similarities or Vocabulary. This suggests that the Lower IQ group may have more general difficulty in the verbal/communication area. It is also possible that this group had a particular comprehension problem in addition, but this was not evident due to a floor effect. The mean score on Comprehension for this group was just above the minimum possible. Thus, the Lower IQ group certainly has general difficulty on the verbal scale, and possibly specific difficulties on the Comprehension test.

Regarding the hypothesis about a peak on the digit-span test, neither group showed a tendency to do particularly well on this task. This confirms the mixed nature of findings regarding the digit-span test.

On the performance scale, both groups show a more similar pattern despite the levels of performance being different. Both groups show the classic peak on the block design and object assembly subtests. The performance of the Lower IQ group on these subtests is in the average range which is in keeping with previous findings which suggest that whatever the level of IQ, autistic subjects score in the average range on the block design test and also often but not always on the object assembly test. However, the performance of the Average IQ group is even more dramatic. This group scored above average on these tests and thus also significantly higher than a stringently matched group of normal controls of similar non-verbal IQ and non-verbal mental age. Such a high level of performance on these tests has not often been reported in previous studies. Only one study (Asarnow et al., 1987) from those reviewed earlier reported mean block design scores in the superior range for the autistic group. One reason for this discrepancy may be that none of the previous studies have used as homogenous a group of autistic subjects as used in the present study. This superior level of ability on the 2 tasks may be peculiar to the subgroup of autistic people with a history of severe classic Kanner's syndrome. Although such subjects must have been included in previous studies, the heterogeniety of the autistic sample may have diluted the picture of superior ability. This finding of superior ability on the 2 tasks in the present sample of Average IQ autistic group challenges the conclusion drawn by Lockyer & Rutter (1970) that the islets of ability defined by these two tests is associated with language retardation in autistic children. The present findings suggest that the islet of superior ability may be related to the severity of the core autistic features rather than to retardation on other functions such as language.

In some studies (for example, Tymchuk et al,1977 and Wolff & Barlow ,1979), performance on the block design test is not found to peak significantly over other performance tests. The autistic subjects in these studies are of very high verbal ability. This suggests that a lack of a significant peak on the block design task is associated with certain subgroups of autistic subjects and adds weight to the suggestion above regarding the link between true islets of ability and specific subgroups.

4.6. Conclusions

It can be concluded from the comprehensive review of the studies in this chapter and the present analysis of the IQ data that there is no single typical IQ test profile accounting for all the subtests for all autistic subjects. However, there is a particular profile on performance subtests for most autistic people.

One consistent finding that emerges is the tendency for all autistic people to perform at least in the average range on the block design task. Their scores on this test do not always represent a significant peak over other performance tests. Whether they do or not seems to depend on the type of autistic subgroup used in the study. Those with high verbal skills do not show the significant peak. On the other hand , autistic subjects with a history of severe classic Kanner's syndrome, non-verbal IQ in the normal range and verbal IQ significantly lower than the performance IQ show not only a peak on the block design and object assembly tests but score in the superior range and significantly higher than normal controls. The results regarding the uneven profile on the performance scale shows that although the overall performance IQ of the Average IQ Autistic group is in the normal range, this does not reflect normalability on all the components of the non-verbal IQ. The 'normal' IQ in fact consists of above-normal ability on two tests and sub-normal ability on the rest of the tests.

On the verbal scale, the findings are more inconclusive. The often reported tendency for autistic people to score very poorly on the comprehension subtest is not held out for all types of autistic subjects. Again, the present results suggest that this may be more true of those autistic subjects with a history of classic Kanner's syndrome. Some autistic subgroups, especially those with high verbal skills do not show this tendency at all. Other subgroups such as the Lower IQ autistic group in the present study score poorly on the comprehension subtest but this is not significantly lower than the scores on the other verbal subtests as this group tends to score poorly on most of the verbal subtests.

The most interesting finding that emerges with regard to the present thesis is the difference between the 2 autistic groups. In the last chapter we discussed the various possible reasons that could account for the link between a high level of non-verbal functioning and the severity of the autistic behaviour in early childhood. The findings regarding the IQ profiles of the 2 groups show clearly that in the Average IQ group, the high non-verbal IQ consists mainly of the very high scores on just 2 tests, the block design and the object assembly. Thus, the link is between islets of superior ability as defined by these 2 tests and severity of the classic autistic features in early childhood.

This chapter establishes that all the autistic people tested here show an islet of at least normal ability on the block design task, and that a particular subgroup shows super-normal ability on the block design and object assembly tasks. The questions that remain are as follows:-

a. <u>How</u> do autistic people achieve normal or super-normal scores on these 2-dimensional visuo-spatial tasks?

b. Is this high level of performance achieved by using normal strategies or does it reflect unusual strategies?

c. Do the differences in the level of performance on these tasks between the two autistic subgroups reflect underlying differences in cognitive processing?

The remainder of the thesis attempts to answer these questions by examining underlying cognitive processes in two-dimensional spatial tasks. The first experiment investigates one basic spatial ability - that of representing spatial position.

4.7. Summary of Chapter (4)

In this chapter, the literature concerning IQ test profiles of autistic people was reviewed. The consistencies and inconsistencies between studies were discussed and qualifications to conclusions normally drawn regarding typical profiles were proposed.

The IQ-test profiles of the subjects in the present studies were then analyzed in detail. The performance of the two autistic groups was analyzed individually, in comparison with each other, and with their respective control groups.

The outstanding findings were as follows. On the Verbal scale, the Average IQ Autistic group showed a specific difficulty on the comprehension subtest. This could not be identified in the Lower IQ Autistic group as they showed a very low level of performance on almost all verbal subtests. On the Performance scale, both groups showed significant peaks on the block design and object assembly subtests. The levels of performance on these differed, depending on overall IQ level. The performance of the Lower IQ group was in the average range but that of the Average IQ group was in the superior range and significantly higher than that of their normal control group.

On the basis of these findings, and the clinical findings reported in Chapter (3), a possible link between superior islets of spatial abilities and the severity of the classic autistic symptoms before age 5 was hypothesized.

CHAPTER FIVE

Experiment 1 - Memory for spatial position

5.1. Introduction

In the search for an explanation as to why autistic children are able to achieve high levels of performance on complex visuo-spatial tasks, it seemed important to start off by establishing whether there were any differences between the two autistic groups and between each autistic group and the relevant control groups on a very basic spatial task. The task chosen was of remembering spatial position in 2-dimensional space.

Memory for knowing where things are in space develops very early, and can be considered, developmentally, the most basic spatial skill. As early as 8 months, babies are able to find objects which they have seen hidden in a particular position (Piaget,1952;1954; Gratch and Landers,1975). However, at this age they continue looking in the same position even if the location is changed. Thus, at this stage, a change in position presents difficulty for the infant. By the age of 12 months, however, the ability to remember position and change in position, over a short period, is well developed.

Discrimination learning experiments also show that position is a powerful cue for discrimination, and constitutes the easiest discrimination learning task for young children (Zeaman & House,1963).

5.1.1. Coding of spatial position

One of the questions that has been pursued regarding coding of spatial position is whether the coding is absolute or whether it is relative to some external framework. Although the precise age is controversial, developmental research (e.g. Butterworth,1975; Bremner & Bryant,1977) generally suggests that the infant starts off using him or herself as a reference point for remembering position. As this becomes less adequate, especially when the infant starts moving around, the infant will begin to relate position to some stable external system instead of to the unstable self (Bremner,1982).

Piaget (1952; 1954) introduced the notion of external frameworks as important reference points to connect and categorize separate perceptual experiences. For example, if one is asked to compare the level of liquid in two glasses, one of which is tilted, it is possible to do so by noting that whatever happens to the glass, the liquid's level always remains parallel to some external feature, like a table top. Piaget referred to this as deductive inference and argued that young children could not use external frames in this way until they are able to make deductive inferences.

Bryant (1974), however, suggests that young children do rely very stongly on framework cues, and use them inferentially in all perceptual judgement. Experimental studies have provided evidence that external frameworks are important in perceptual judgements about size (Rock, 1966), orientation and position (summarized in Bryant, 1974). It is suggested that young children initially remember position, orientation, etc., only through their relationships to features of the background. As they grow older, they are not totally dependent on these background relationships because they begin to acquire internal categories which form the basis of an absolute code. However, even when absolute codes are available, the tendency to use background cues remains very strong. Although most of the experiments have been done only on children, Bryant (1974) acknowledges that this tendency persists into adulthood. Although adults are better than children at remembering absolute codes, they tend to use relative values and ignore absolutes when they can.

5.1.2. Experimental evidence for framework effects

The effects of framework in coding position and orientation have been mainly investigated using 2-dimensional tasks. For example, in one experiment (Bryant, 1974) young children had to make successive comparisons between two oblique lines or between horizontal and vertical lines. Children found the former discrimination more difficult. This is because, for oblique lines, there is no appropriate framework in the surroundings with which to match it. When appropriate cues for the oblique were presented (i.e. a thick red oblique line which was parallel to the standard line), the children were able to make successive comparisons between the obliques more easily. Relative coding of position was investigated by experiments which required children to make simultaneous comparisons of positions of dots. Children were presented with a drawing of 3 squares as shown in Figure 5.1. Their task was to say which of the two outside squares was identical to the one in the centre. The results showed that such tasks which children normally find difficult, can be made much easier by providing an appropriate framework reference as shown in Figure 5.2. The additional reference

Figure 5.1

SPATIAL TASK WITHOUT APPROPRIATE FRAMEWORK REFERENCE (BRYANT, 1974)

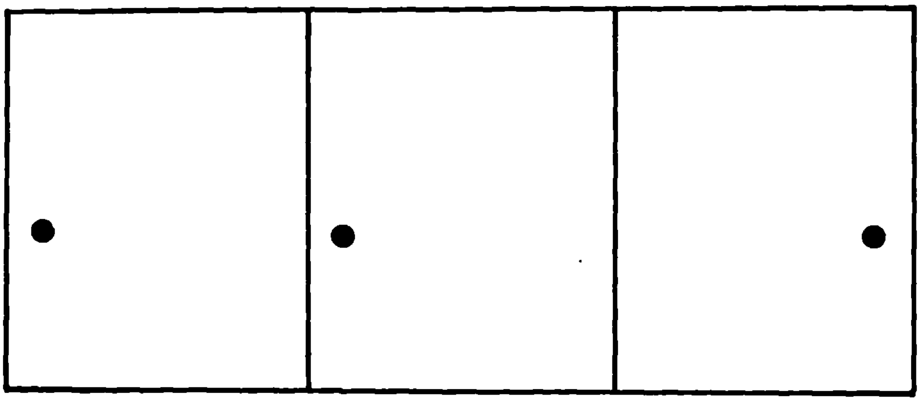
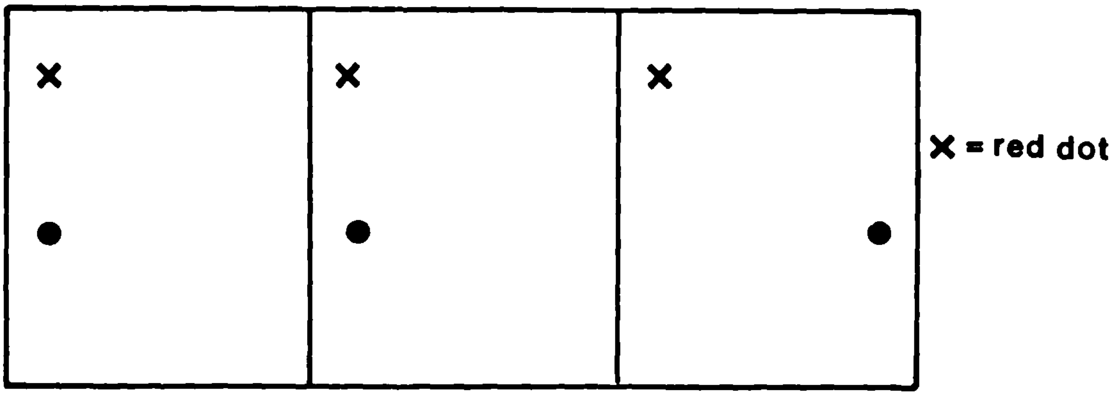


Figure 5.2

SPATIAL TASK WITH APPROPRIATE FRAMEWORK REFERENCE (BRYANT, 1974)



point (the standard red dot) makes the discrimination easier as the child can judge whether the two dots are 'in line' or 'out of line'.

Other evidence which suggests that normal perception is dominated by the broader frames of reference is provided by experiments about interference caused by frameworks. Witkin et al. (1971) have shown these effects on a number of tasks. One task, called the rod and frame, requires the subject to set a luminous rod to true vertical when the rod is surrounded by a luminous square frame in an otherwise completely dark room. Children and many adults tend to be influenced by the frame's orientation and thus if it is tilted, they set the rod in the same direction. The Embedded Figures Test (Witkin et al., 1971) represents a two-dimensional test of the ability to resist framework effects. On this test, the subject is required to find figures which are hidden as parts of larger caricatured drawings of objects (interfering frameworks). There is a high correlation between subjects' performance on such tasks. The body of research on this suggests that there is individual variation in the susceptibility to framework effects and in general children show a higher degree of error on these tasks (Witkin & Goodenough, 1981).

5.1.3. Framework effects in autism

Descriptions of autistic children in the literature (Wing,1976) suggest that they show a remarkable ability at locating things in confusing backgrounds (e.g., a tiny tablet dropped on a multi-coloured carpet). This, together with reports regarding their tendency to react to very small and specific changes in the environment, suggests that they may have a greater tendency to use absolute rather than relative codes. The normal tendency to use relative codes has the disadvantage of not enabling registration of details of individual stimuli.

The musical skills shown by many autistic children are also suggestive of a superior ability to code absolute values. Applebaum et al (1979) found that autistic children were equally good or better at imitating tones on the basis of pitch, rhythm and duration than age-matched normal children who had considerable musical experience. Wing (1976) has described autistic children who are able to identify a piece of music after hearing a few bars, or to recognize, from the first bar when a record familiar to them is being played at the wrong speed. They also seem able to differentiate between two consecutive individual tones on the basis of their absolute frequency.

The abnormality of communication, echolalia, a typical characteristic of verbal autistic children, shows they are able to store long strings of items in memory in the exact form in which they were first experienced. This is substantiated by evidence from a series of experiments by Hermelin, O'Connor, and Frith (summarized in Hermelin & O'Connor, 1970 and in Hermelin & Frith, 1971). These experiments, which required subjects to remember material of varying degrees of structure and meaning, showed that autistic children tended to code words, colours etc. as separate absolute units rather than as parts of larger meaningful frameworks.

The most direct evidence regarding lack of framework interference is provided by the experiment which investigated their performance on the Children 's Embedded Figures Test (Shah & Frith, 1983). Autistic children performed significantly better on this task than the normal control group matched on mental age and the mentally retarded control group matched on CA and MA. Thus, on this two-dimensional task they were less influenced by the interfering framework. In view of the high correlation reported in the literature between performance on the embedded figures and other related tests such as the rod and frame test (Witkin et al., 1971), the autistic children's performance on the CEFT may be reflecting a more general tendency to be unaffected by framework effects.

5.2. Aims and Hypotheses

The general aim was to investigate the strategies used by autistic children on a basic spatial task, that of remembering position in two-dimensional space. The following specific aims and hypotheses arose out of the evidence reviewed regarding the strategies used by normal children to code position, and the evidence regarding a possible tendency of autistic children to be unaffected by contextual frameworks.

1. The first aim was to compare the accuracy of the 5 groups of subjects described in Chapter (2) at remembering spatial position. This ability has not been investigated in autistic people before. Thus, no firm prediction could be made on the relationship between their accuracy on this task and that of the other non-autistic groups. Since the ability to remember spatial position develops very early in normal infants, it was unlikely that there would be great differences between any of the groups regarding overall

accuracy.

2. The second aim was to investigate whether both the autistic groups used the same cognitive/perceptual strategy for coding spatial position as their controls. It was hypothesized that the performance of the autistic groups would not be significantly affected when appropriate framework cues were provided. The control groups, on the other hand, being more dependent on a relative code, were predicted to improve in accuracy when relative coding was made easier by the appropriate framework at the input and the output stages.

3. The third aim was to investigate the stability of the position code for the different groups, i.e. to what extent did inappropriate framework cues affect the accuracy of the position code. It was hypothesized that, since the autistic groups would not rely on the external framework, their performance would be less affected by the presence of incongruent frameworks at the input and output stages. Thus, their accuracy on these conditions would be the same as on the basic neutral condition. For the control groups, however, the incongruent frameworks would have an interfering effect and thus they would be less accurate on these conditions than on the neutral condition.

4. The fourth aim was to investigate the effect of the oblique line in the framework. It was hypothesized that the performance of the control groups would be affected even more severely when one of the inappropriate backgrounds consisted of oblique lines. The presence of oblique lines in the background would not affect the accuracy of the autistic groups.

5.3 Methods

5.3.1. Subjects

There were 5 groups of subjects as described in Chapter (2). The subjects in the 2 autistic groups were the same as described in Table 2.1 except that one subject in each group did not participate in this experiment. The composition of subjects in the non-autistic groups was the same as described in Table 2.2. The subject details are summarized Table 5.1.

5.3.2. Design and Materials

The basic paradigm used to study memory of spatial position was as follows. The subject was shown an A4 size page with an X marked on it in a random position (input). The subject's task was to remember the position of X and mark it on another A4 page (output).

The various aims of the experiment were investigated by varying the input and output backgrounds. Four different backgrounds were used. These are illustrated in Figure 5.3.

Basic accuracy was investigated by having the input and output background as plain. Thus, although the periphery of the page was an implied framework, no definite superimposed framework was provided. This condition of plain (P) input and plain (P) output will be referred to as PP.

The coding strategy was investigated by providing a super-imposed grid of small squares on the page at both input and output. This provided a definite framework to which the position of the X could be related. This condition of small-squares input and small-squares output will be referred to as SS. To see whether this framework was necessary at both

TABLE 5.1.
Subject characteristics in Experiment 1

	Average IQ autistic	Older normal	Lower IQ autistic	Younger normal	Lower IQ non-autistic
Chronological Age					
X	18.7	16.0	18.8	10.9	17.8
sd	1.8	0.6	3.1	0.3	2.5
N	9	17	9	16	12
Performance IQ					
X	97.6	100.6	72.3	105.6	76.3
sd	8.3	7.1	5.2	5.5	5.5
N	9	17	8	16	12
Verbal IQ					
X	73.3	NA	55.8	NA	74.5
sd	15.8		8.4		8.0
N	9		8		11
Block Design scaled score					
X	14.6	11.4	9.7	11.0	6.3
sd	2.8	2.0	2.4	1.5	1.9
N	9	17	9	16	12

Table 5.2.
Order of presentation for the different conditions

Trial No.	Condition	Input background	Output background
1-4	PP	plain	plain
5-8	SS	small squares	small squares
9-12	SP	small squares	plain
13-16	PS	plain	small squares
17-20	SR	small squares	rectangles
21-24	RS	rectangles	small squares
25-28	ST	small squares	triangles
29-32	TS	triangles	small squares

TABLE 5.3.
Means and std. dev. on PP

	Groups				
	Average IQ Autistic	Lower IQ Autistic	Older Normal	Younger Normal	Lower IQ Non-Autistic
N	9	9	17	16	12
Mean (cms)	7.4	9.4	7.9	9.8	10.6
SD	2.0	2.7	1.6	2.9	2.9

Figure 5-3

BACKGROUNDS

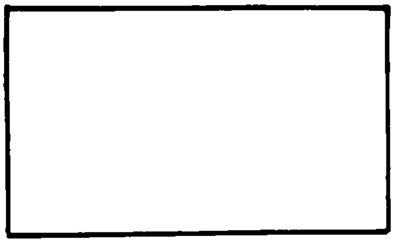
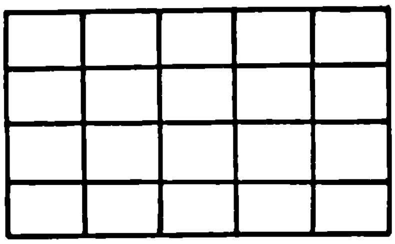
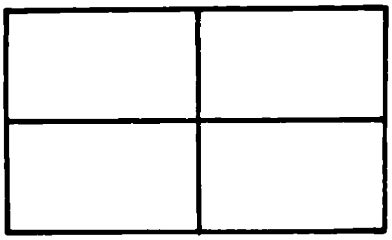
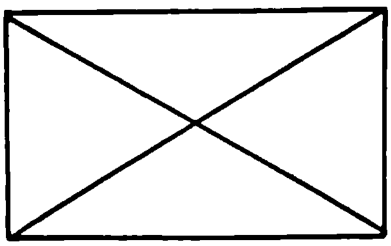
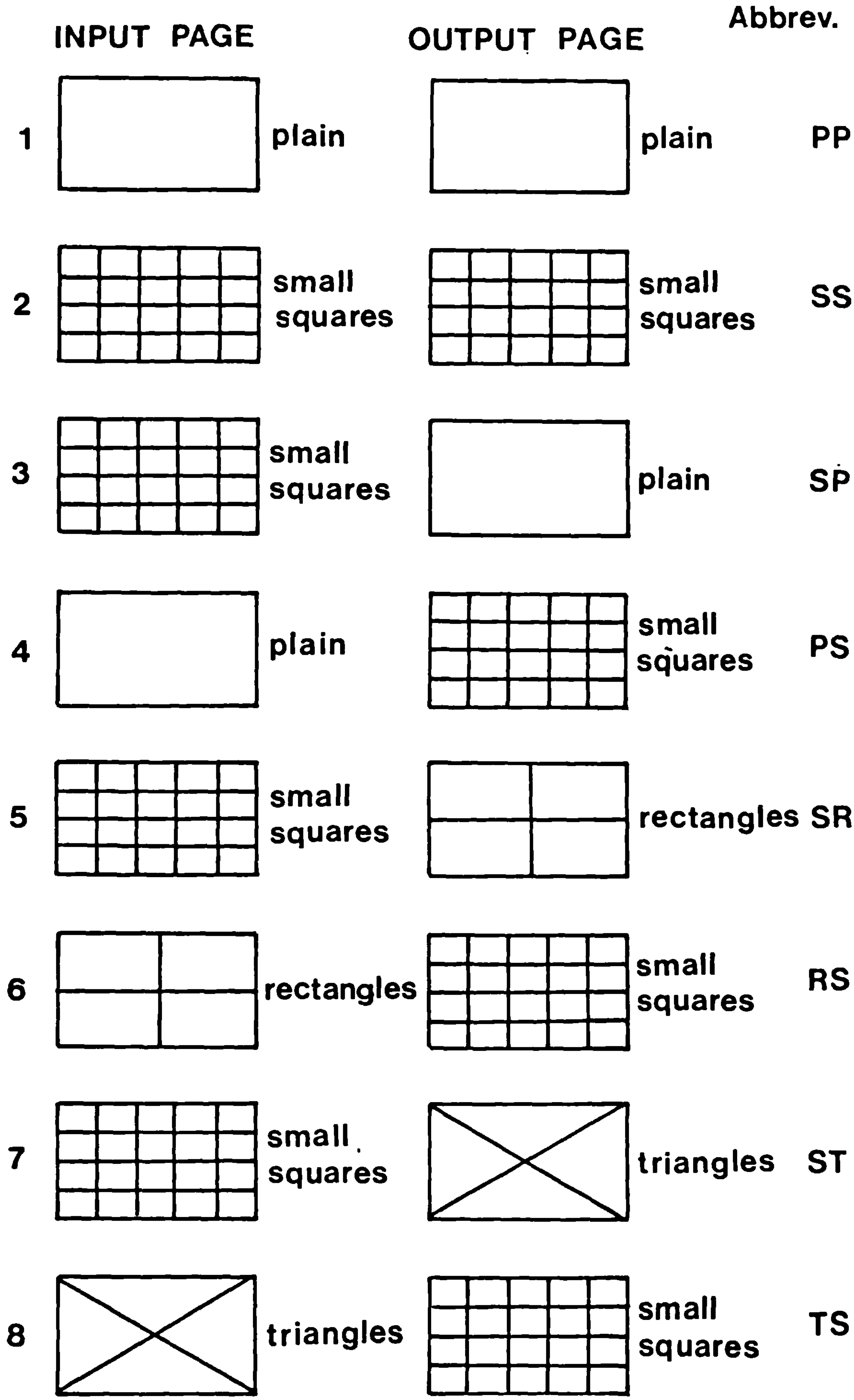
	ILLUSTRATION	DESCRIPTION	Abbrev.
1		Plain	P
2		Black lines dividing the page into a grid of 20 small 2-inch Squares	S
3		Black lines dividing the page into 4 large Rectangles	R
4		Black oblique lines dividing the page into 4 Triangles	T

Figure 5.4

INPUT-OUTPUT COMBINATIONS



the input and output stages, two other conditions were used. These were condition SP in which the grid of small squares was provided only at the input stage, and condition PS in which the grid was only provided at the output stage.

The stability of the position code was examined by using conditions in which the input and output conditions were incongruent. These included condition SR where the input background consisted of small squares and the output background was of large rectangles, and condition RS where these input and output backgrounds were reversed. The interference caused by oblique lines in the framework was examined by having conditions ST and TS in which one of the incongruent backgrounds consisted of oblique lines dividing the page into triangles.

The input-output combinations for the 8 conditions described above are illustrated in Figure 5.4. There were four trials for each condition. The order of presentation and the input-output frameworks for each of the 32 trials are described in Table 5.2.

Materials

The input stimulus material consisted of a booklet with 32 A4 size pages. Each page had an X marked on it in black in a random position, and one of the four backgrounds shown in Figure 5.3. The order of the backgrounds in the stimulus booklet corresponded to the order of the input backgrounds for the 32 trials described in Table 5.2.

The output material for the subject consisted of an A4 page, again with any of the four possible backgrounds. Instead of using 32 separate pages for the subject to work on, the subject was provided with a 2-page booklet with a carbon-paper in between. There were four such booklets, each having one of the frameworks on the top-page. The subject was also provided with a pen wihout any ink. This was used to mark the X on the top page. Thus, the mark was left only on the bottom page without the top page being affected. This procedure ensured that although the subject used each 2 page booklet for up to 16 trials, there was no interference from the X marked from preceding trials.

5.3.3. Procedure

Each subject was tested individually. The examiner and the subject sat opposite each other across a table. The procedure was demonstrated to the subject by using practice booklets. First, the use of the carbon-paper and the inkless pen were explained to the subject. The subjects were encouraged to mark with the pen on the practice booklet and then look at the bottom page. After they got used to marking with the inkless pen, the test procedure was demonstrated. The examiner opened a page from the practice booklet and asked the subject to try to remember where the X was placed. After shutting the page of her booklet, the examiner asked the subject to mark the X in exactly the same place on his/her booklet. The subject's response was verified by placing a transparent sheet with the X marked over the subject's page. The need for accuracy was stressed. This practice procedure was repeated 5-10 times, until the examiner felt satisfied that the subject understood exactly what he or she had to do. The subject was also shown the 4 backgrounds which could occur at input or output, and explained that their task always remained the same. The subject was then given the first booklet (plain) to work on and testing commenced. On each trial, the examiner opened a page of the input booklet which was aligned with the subject's booklet. This page was exposed for 2 seconds. Immediately after the stimulus had been removed, the subject marked the X on his or her booklet and numbered it according to the trial number. After 4 trials, the subject was given another booklet with the appropriate output background. This procedure was repeated for each set of 4 trials.

5.3.4. Scoring

A transparent scoring key was used to measure the subject's accuracy on each trial. Four scoring keys were prepared - one for each booklet. The key consisted of eight X marked in the test positions. The appropriate key was placed over the subject's page and the distance between the test X and the subject's X measured to the nearest centimetre. Thiry-two scores were thus produced for each subject, each score representing deviation (in centimetres) from the target. The minimum possible score was 1 and reflected most accuracy, i.e. within 1 cm. The maximum possible score was 20 as the length of the page was 20 cms.

5.4. Results

For each subject, the deviation scores over the 4 trials of each of the 8 conditions were summed to give an overall score for each condition. These scores for individual subjects in each group are given in Appendix (13). These overall summed scores are used as single scores in the following analysis. The minimum score reflecting maximum accuracy is thus 4. It should be noted that this does not mean 4 cm deviance. To obtain the actual deviance, the values reported below have to be divided by 4.

The results were to be analyzed using analysis of variance statistics. As this procedure assumes an underlying normal distribution of the data, it was important first to establish that the data was not unduly skewed. This was done by examining frequency distributions for each condition for each group. Although some of the distributions were positively skewed, the majority were found to be normal. Thus, no transformation was applied to the data.

5.4.1. Accuracy on the basic task

This was investigated using the scores on the PP condition. Both the input and output backgrounds were plain on this condition. The means and the standard deviations for the 5 groups on PP are shown in Table 5.3.

The performance of all the 5 groups was compared using a one-way ANOVA procedure. The main effect of group was significant which means that the groups were performing differently on this basic task. The means in Table 5.3 show that the Lower IQ Non-Autistic group was the least accurate. Post-hoc paired comparisons showed that the performance of this group was significantly different from that of the Average IQ autistic group and the Older Normal group (Student Newman-Keul test and Tukey test, $p<.05$), but was not significantly different from the Lower IQ Autistic Group and the Younger Normal group. The Average IQ Autistic group and the Older Normal group did not perform significantly differently - in fact, their mean deviation scores were virtually identical. The mean deviation scores of the Lower IQ Autistic group and the Younger Normal group were very similar. These 2 groups were less accurate than the Average IQ Autistic group and the Older Normal group, but this difference did not reach significance on the post-hoc comparisons.

5.4.2. Coding Strategies

To test out the other hypotheses, performance on each condition was compared to the PP condition to see whether any manipulations of the basic task affected accuracy. This procedure, rather than an analysis of all the variables together using a multivariate procedure, was justified as each separate analysis tested out specific hypothesis formulated at the outset. The results are analyzed using Analysis of Variance for Repeated Measures. For each hypothesis, 2 sets of analyses were carried out. The Average IQ Autistic group was compared with the Older Normal group, and the Lower IQ Autistic group was compared with the Younger Normal group and the Lower IQ non-autistic group. For each analysis, there was one grouping factor and one trial factor. The mean deviation scores for all the conditions for each set of groups are shown in Tables 5.4 and 5.5.

5.4.2.1. Absolute vs Relative coding

5.4.2.1.1. The effect of the grid framework present at input and output

To see if the coding of the spatial position was done relative to the external frame, performance on the PP condition was compared to the SS condition. On the SS condition the background at input and output consisted of a

TABLE 5.4.
Deviation scores (cms) on all conditions:
Average IQ Autistic and Older Normal groups

	Average IQ Autistic (N=9)		Older Normal (N=17)	
	Mean	(SD)	Mean	(SD)
Condition				
PP	7.4	(2.0)	7.9	(1.6)
SS	4.8	(0.8)	6.9	(2.2)
SP	8.2	(3.5)	9.3	(2.3)
PS	8.9	(3.1)	8.5	(1.9)
SR	9.4	(3.8)	11.1	(3.6)
RS	11.1	(5.8)	11.5	(4.8)
ST	8.6	(2.6)	10.8	(3.7)
TS	9.8	(2.7)	9.9	(4.2)

TABLE 5.5.
Deviation scores (cms) on all conditions:
Lower IQ Autistic, Younger Normal and
Lower IQ Non-Autistic groups

	Lower IQ Autistic (N=9)		Younger Normal (N=16)		Lower IQ Non-Autistic (N=12)	
	Mean	(SD)	Mean	(sd)	Mean	(SD)
Condition						
PP	9.4	(2.7)	9.8	(2.9)	10.6	(2.9)
SS	5.1	(1.1)	6.3	(1.1)	6.8	(2.0)
SP	11.1	(3.3)	11.8	(4.3)	13.8	(4.8)
PS	10.7	(3.7)	10.8	(2.8)	14.1	(6.4)
SR	11.2	(2.9)	10.1	(3.2)	13.4	(5.4)
RS	14.2	(4.8)	13.1	(3.2)	14.5	(5.6)
ST	12.9	(2.8)	11.9	(3.8)	12.5	(3.7)
TS	12.3	(5.2)	10.6	(3.4)	14.0	(5.6)

grid of small squares. If the subjects were using a relative code, their accuracy on SS should be higher than that for PP as the small squares provided a definite framework to which the position of the target could be related.

a. Average IQ Autistic vs Older Normal

The mean deviation scores for PP and SS for these 2 groups are shown in Table 5.4. and plotted in Figure 5.5. There was no significant interaction between group and condition. However, there was a significant main effect of condition ($F_{(1,24)}$=11.7 P<.001), and of group ($F_{(1,24)}$=5.68;P<.02). This means that although the SS condition affected the performance of both groups, there was a significant difference between the group means. This difference can be clearly seen in Figure 5.5. Both groups show more accurate performance on the SS condition compared to the PP condition, but the improvement is greater for the Average IQ Autistic group. In fact although the groups started off equally on the PP condition, there is a significant difference between their deviation scores on the SS condition (t=2.71;df=24;p<.01) . The Average IQ Autistic group shows a much larger improvement in accuracy when definite framework cues are provided. As shown in Table 5.4, their mean deviation score on SS is very close to the minimum possible score of 4.

b. Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic groups

The means for PP and SS are given in Table 5.5. There was no significant interaction between group and

Figure 5.5

COMPARISON OF PP AND SS SCORES: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS

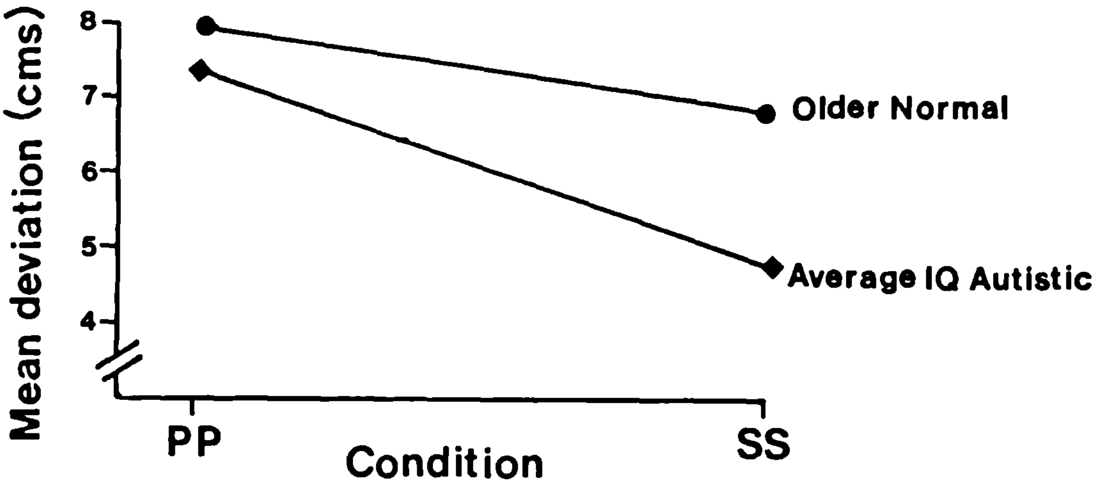


Figure 5.6

COMPARISON OF PP AND SS SCORES: LOWER IQ AUTISTIC, YOUNGER NORMAL AND LOWER IQ NON-AUTISTIC GROUPS

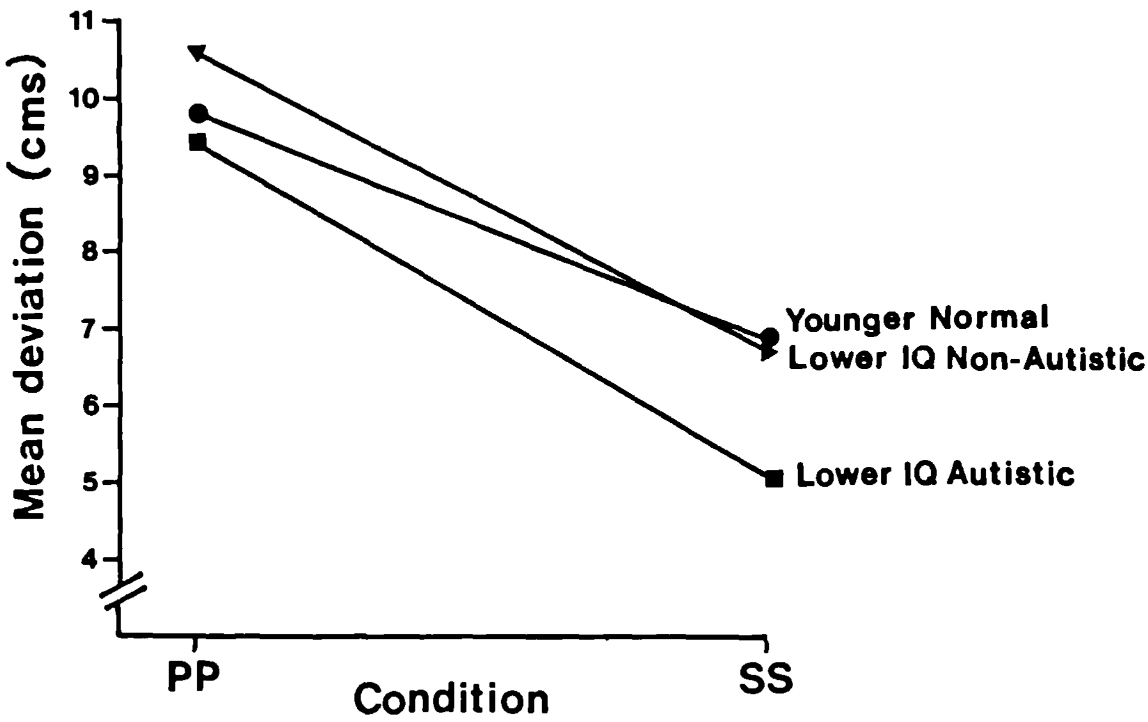


Figure 5.7

COMPARISON OF PP AND SP SCORES: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS

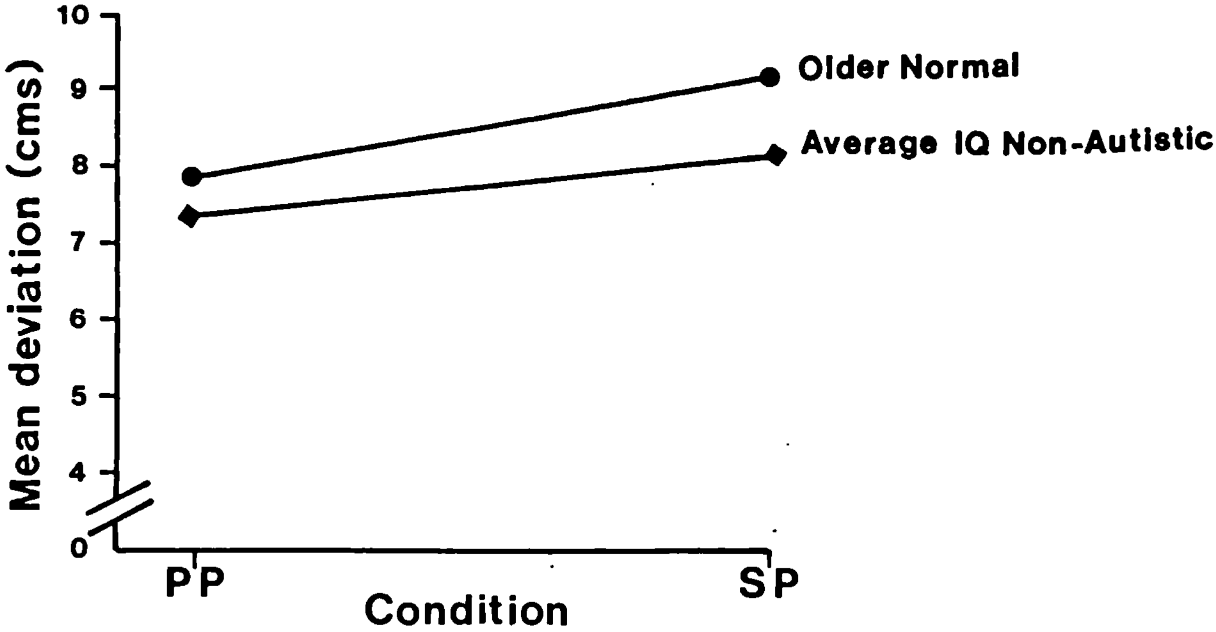
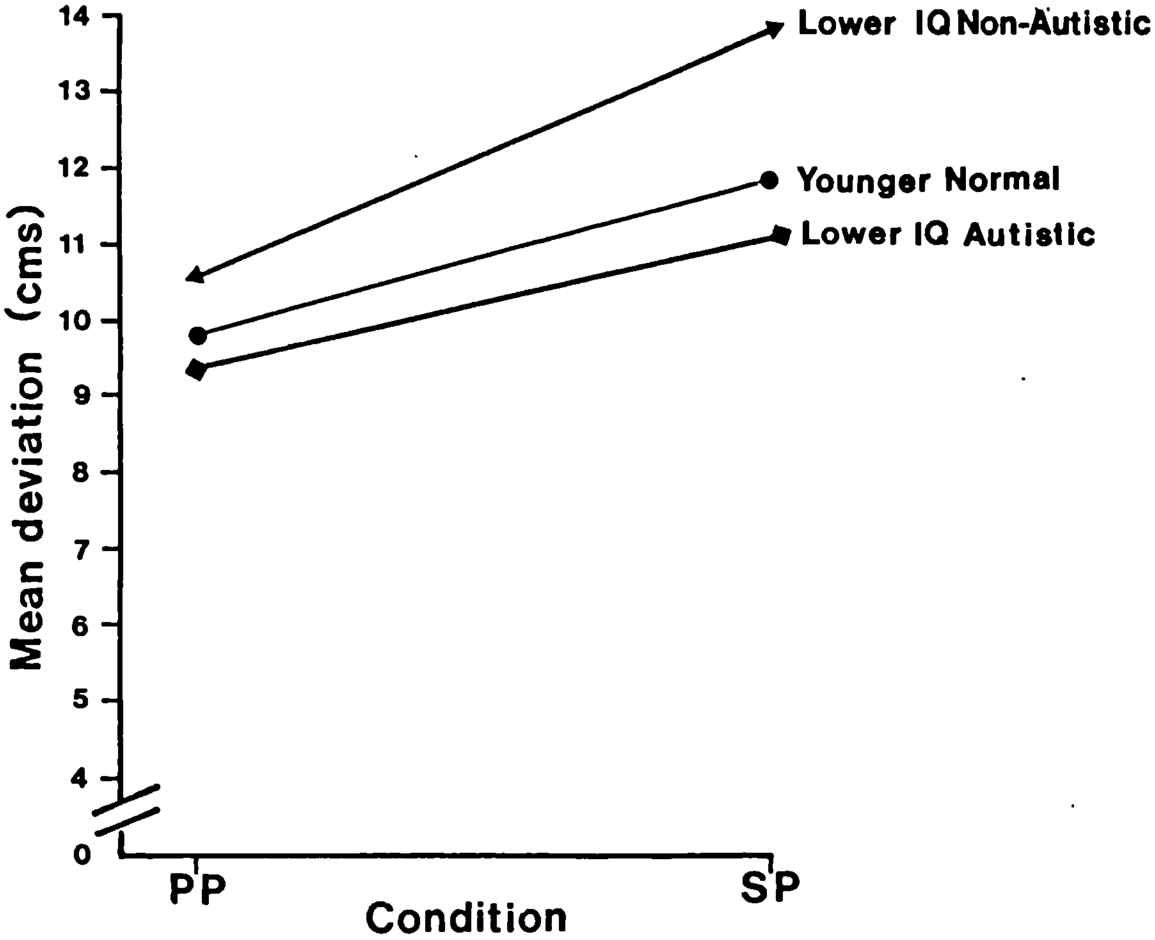


Figure 5.8

COMPARISON OF PP AND SP SCORES: LOWER IQ AUTISTIC, YOUNGER NORMAL AND LOWER IQ NON-AUTISTIC GROUPS



condition. There was a significant main effect of condition ($F_{(1,35)}=60.69; p<.001$), but not of group. This means that the condition had the same effect for all 3 groups, and that there are no significant differences between the group means. These results are plotted in Figure 5.6.

5.4.2.1.2. The effect of the grid framework present at input only

Since all the groups were helped by the presence of the grid framework at both input and output, the results were analyzed to see whether having the grid only at the input stage or only at the output stage would have any effect on accuracy.

The effect of the input only condition were analyzed by comparing the performance on PP with SP. It will be recalled that in condition SP, the page on which the target was presented had the grid framework on it, but the page on which the subject indicated the location was plain.

a. Normal IQ Autistic and Older Normal

There was no significant interaction between group and condition. There were no significant main effects of group or of condition either. Thus, as shown in Figure 5.7, the presence of the grid only at the input stage did not affect the performance of either of these 2 groups to a great extent. It is worth noting, however, that for both groups there was a slight deterioration in accuracy. This was more pronounced for the Older Normal group. The group means for SP are shown in Table 5.4.

b. Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic

The group means for SP are shown in Table 5.5 and plotted in Figure 5.8. There was no significant interaction between group and condition. There was no significant main effect of group but there was a significant main effect of condition ($F_{1,35}=12.68; p<.001$). Thus, the presence of the grid at input only was having an effect on the accuracy for all 3 groups. The means in Table 5.5 and Figure 5.8 indicate that for all groups, there was a deterioration in accuracy on the SP condition compared to the accuracy on the basic (PP) task. The accuracy level of the Lower IQ Non-Autistic group was the most affected.

5.4.2.1.3. The effect of the grid framework present at the output stage only

This was investigated by comparing the accuracy on the basic (PP) condition with that on the PS condition. On the PS condition, the page on which the target was presented was plain, but the page on which the subject responded had the grid framework.

a. <u>Normal IQ Autistic and Older Normal</u>

The results for these 2 groups are given in Table 5.4 and plotted in Figure 5.9. No significant interaction was found between Group and Condition. There were no significant effects either of Group or Condition alone. Thus, the presence of the grid at the output stage only did not affect the performance of these 2 groups. In fact, for the autistic group, the means for PP and SP were identical. For the Older Normal group, accuracy on PS was only slightly lower than that for PP.

Figure 5.9

COMPARISON OF PP AND PS SCORES: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS

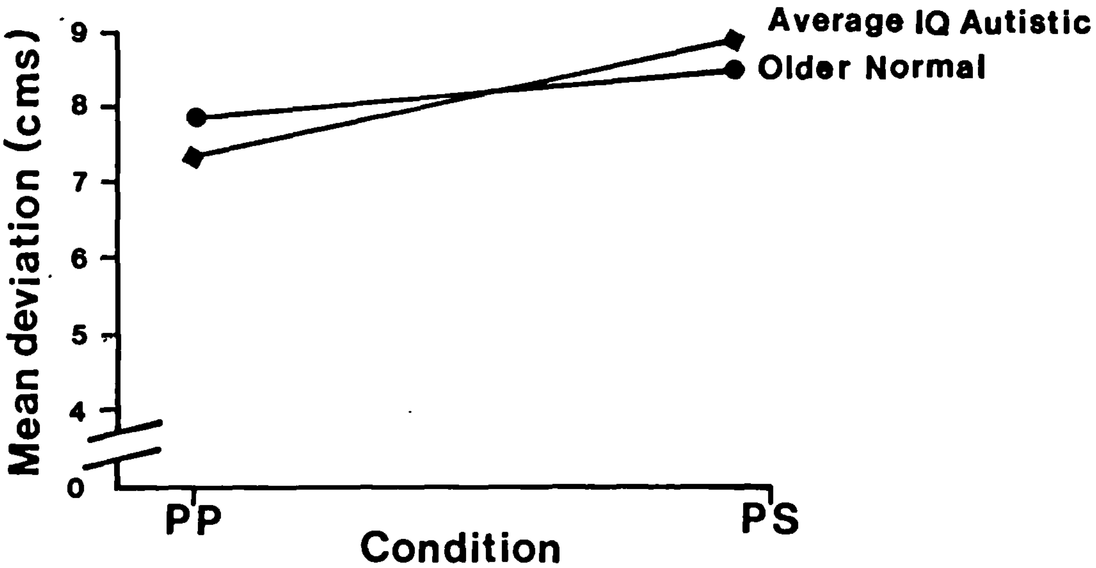
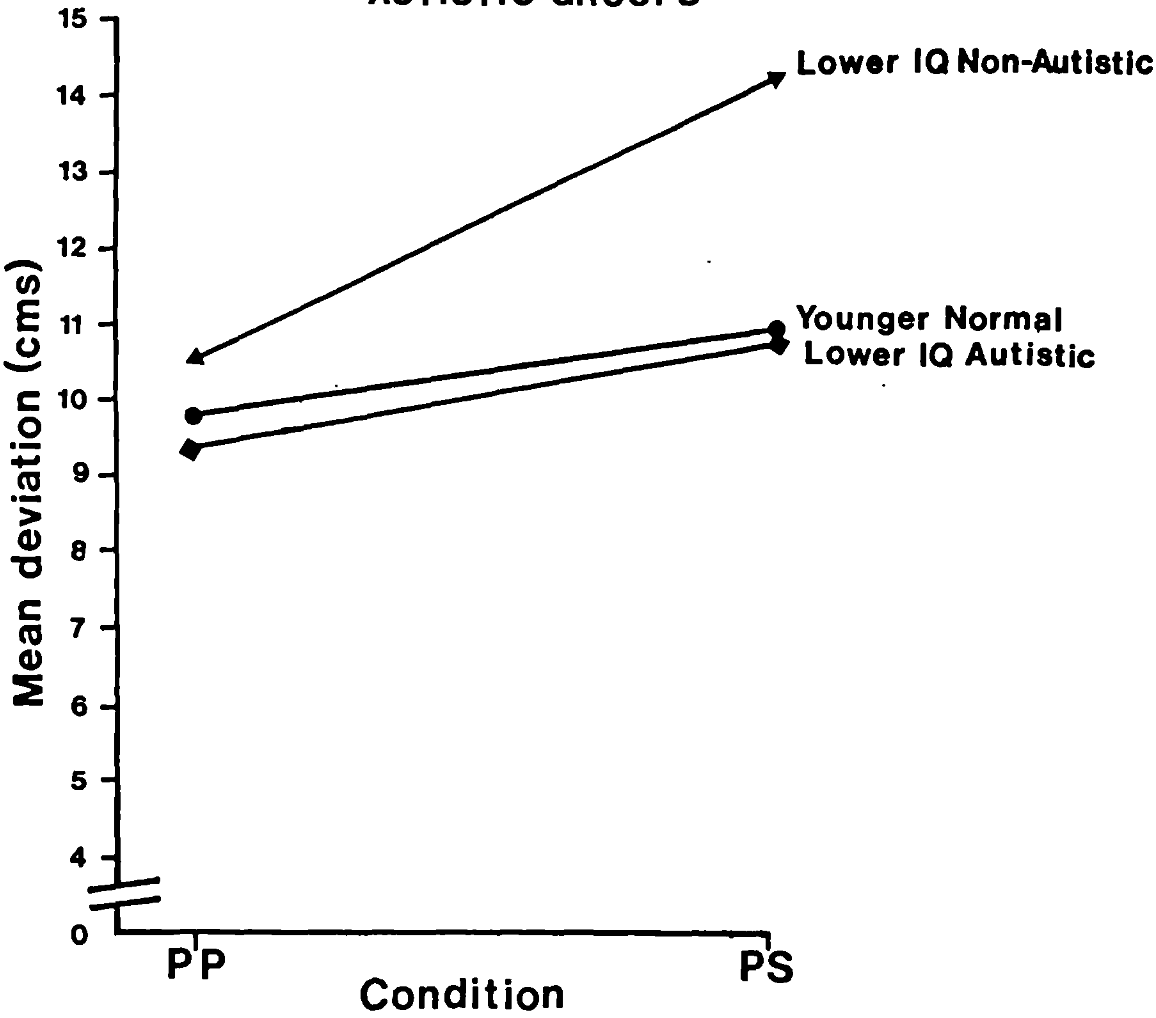


Figure 5.10

COMPARISON OF PP AND PS SCORES: LOWER IQ AUTISTIC, YOUNGER NORMAL AND LOWER IQ NON-AUTISTIC GROUPS



b. Lower IQ autistic, Younger Normal and Lower IQ Non-Autistic

The means for PS are given in Table 5.5 and are plotted in Figure 5.10. Although, there was no significant interaction between Group and Condition, the main effect for Condition was found to be significant ($F_{1,35}=8.71; p<.01$). This is illustrated in Figure 5.10 and shows that the presence of the grid at the output stage had an effect on the performance of all 3 groups. The results for the Autistic group and the Normal group are very similar, but the Non-Autistic group shows the most striking effect of the condition.

5.4.3. Stability of the position code

This was investigated by comparing the performance on the basic (PP) condition to the conditions where the input and output backgrounds were incongruent.

5.4.3.1. The effects of incongruent backgrounds without any diagonals

The two conditions of relevance here were 1) SR where the input background consisted of the grid of small squares and the output background consisted of large rectangles, and 2) RS where these 2 backgrounds were reversed for input and output.

a. Average IQ Autistic and Older Normal

As there was no difference between the means of SR and RS conditions for either group, the scores of these 2 conditions were combined for each subject to give a single mean score. In the analysis, the means for PP were compared to these combined means of SR and RS, referred to from now as SRS. The means are given in Table 5.4 and are plotted in Figure 5.11. Analysis of the data revealed no significant interaction between Group and Condition, but did show a significant main effect for Condition ($F_{1,24}=13.82; P<.001$). Inspection of Table 5.4 and Figure 5.11 shows that the incongruent backgrounds reduced the accuracy of both the groups.

b. Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic

The means of SR and RS were different for these 3 groups, and hence the results for these 2 conditions were analyzed separately.

PP vs SR - There was no significant interaction, but the main effect for Condition was significant ($F_{1,35}=4.46; p<.05$). As can be seen from Figure 5.12, the presence of incongruent backgrounds reduced the accuracy of all 3 groups. The Lower IQ Non-Autistic group was affected the most and the Younger Normal group the least.

PP vs RS - The only significant result here was the main effect for Condition ($F_{1,35}=29.46; p<.001$). As shown clearly in Figure 5.13, accuracy in all 3 groups was greatly reduced by this condition. Figures 5.12 and 5.13 show clearly that the performance of the Lower IQ Autistic group and the Younger Normal group was much more affected by condition SR than condition RS.

Figure 5.11

COMPARISON OF PP AND SRS SCORES: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS

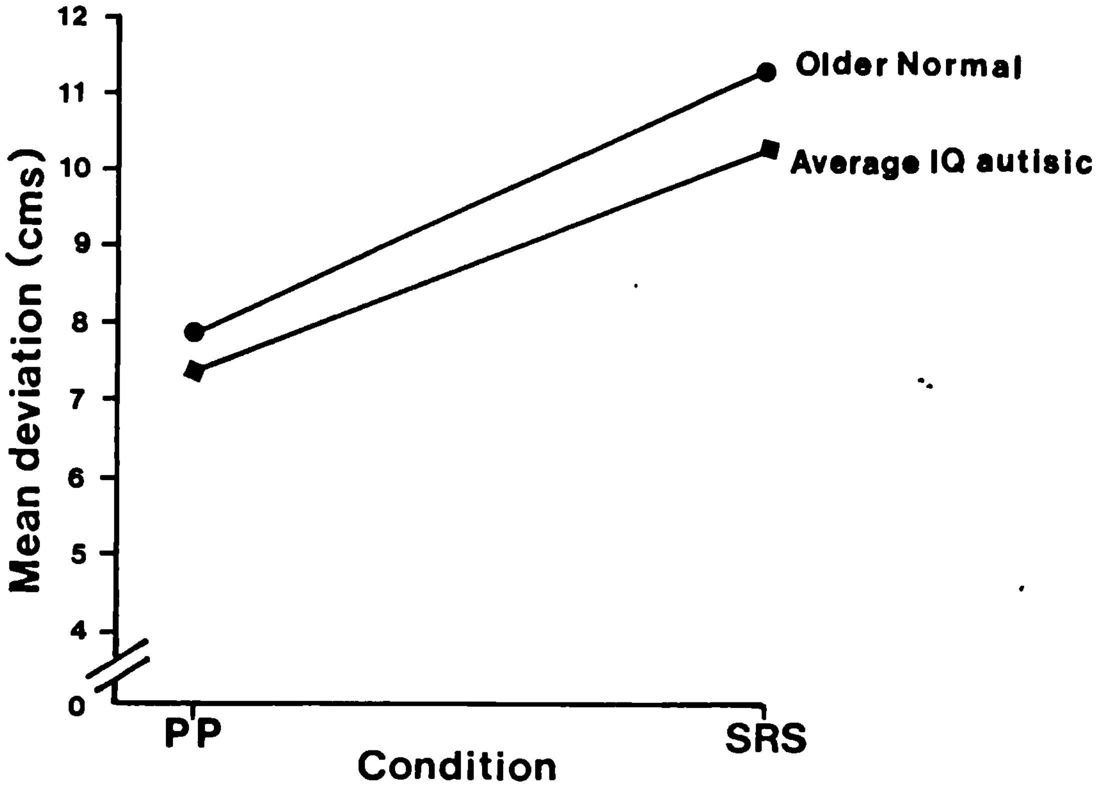


Figure 5.12

COMPARISON OF PP AND SR SCORES: LOWER IQ AUTISTIC, YOUNGER NORMAL AND LOWER IQ NON-AUTISTIC GROUPS.

Figure 5.13

COMPARISON OF PP AND RS SCORES: LOWER IQ AUTISTIC, YOUNGER NORMAL AND LOWER IQ NON-AUTISTIC GROUPS

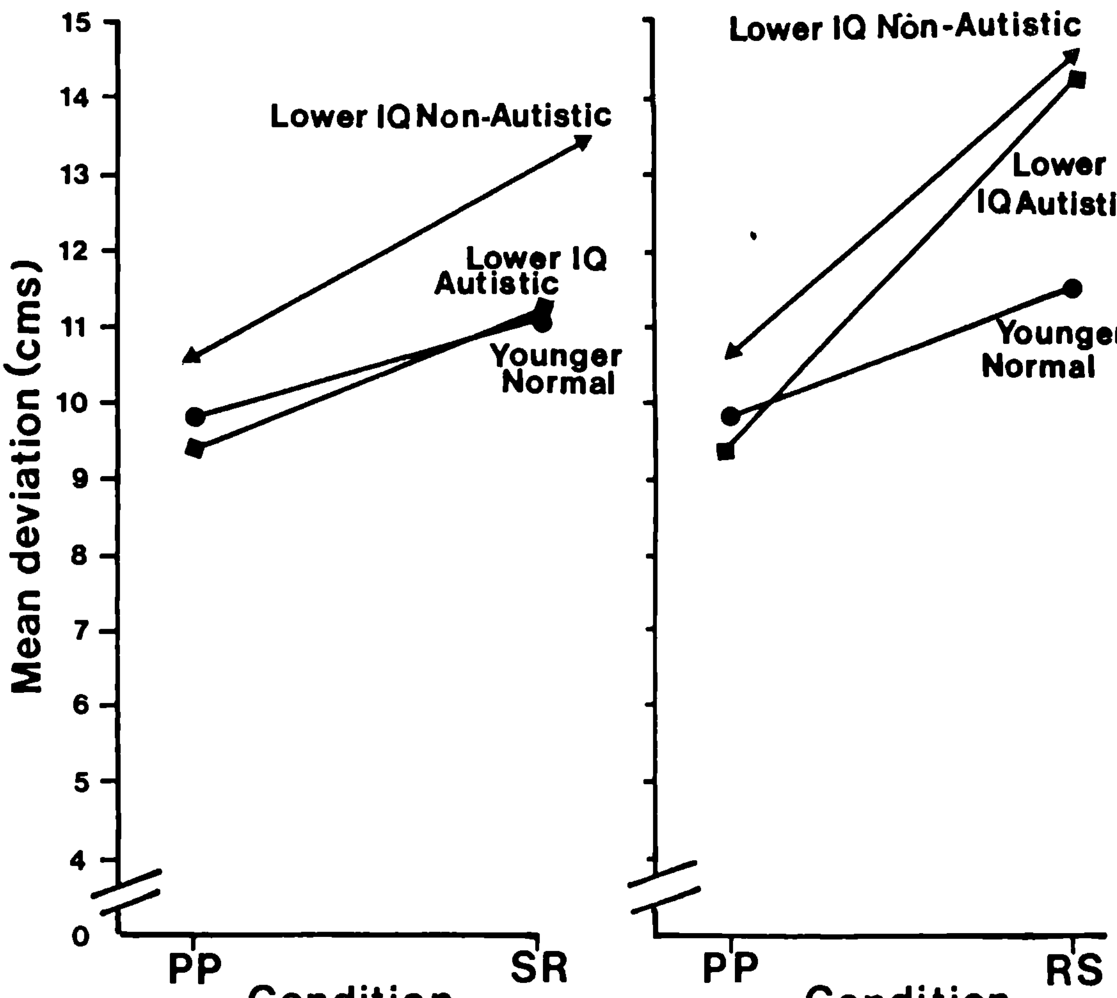


Figure 5.14

COMPARISON OF PP AND STS SCORES: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS

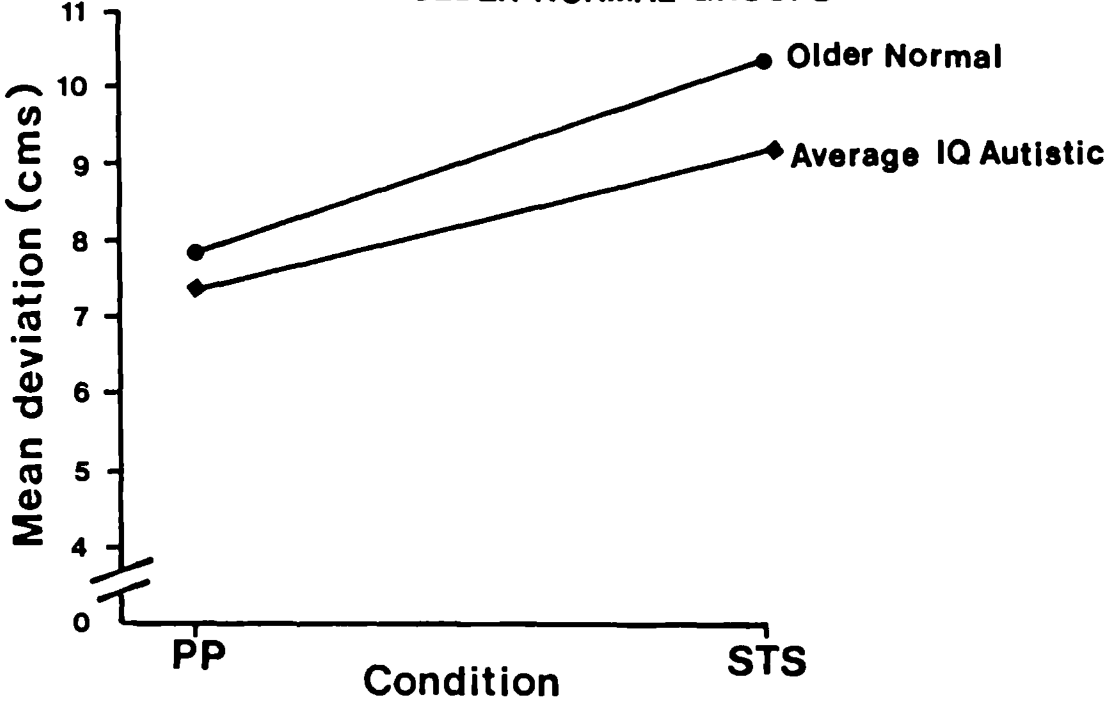


Figure 5.15

COMPARISON OF PP AND STS SCORES: LOWER IQ AUTISTIC, YOUNGER NORMAL AND LOW IQ NON-AUTISTIC GROUPS

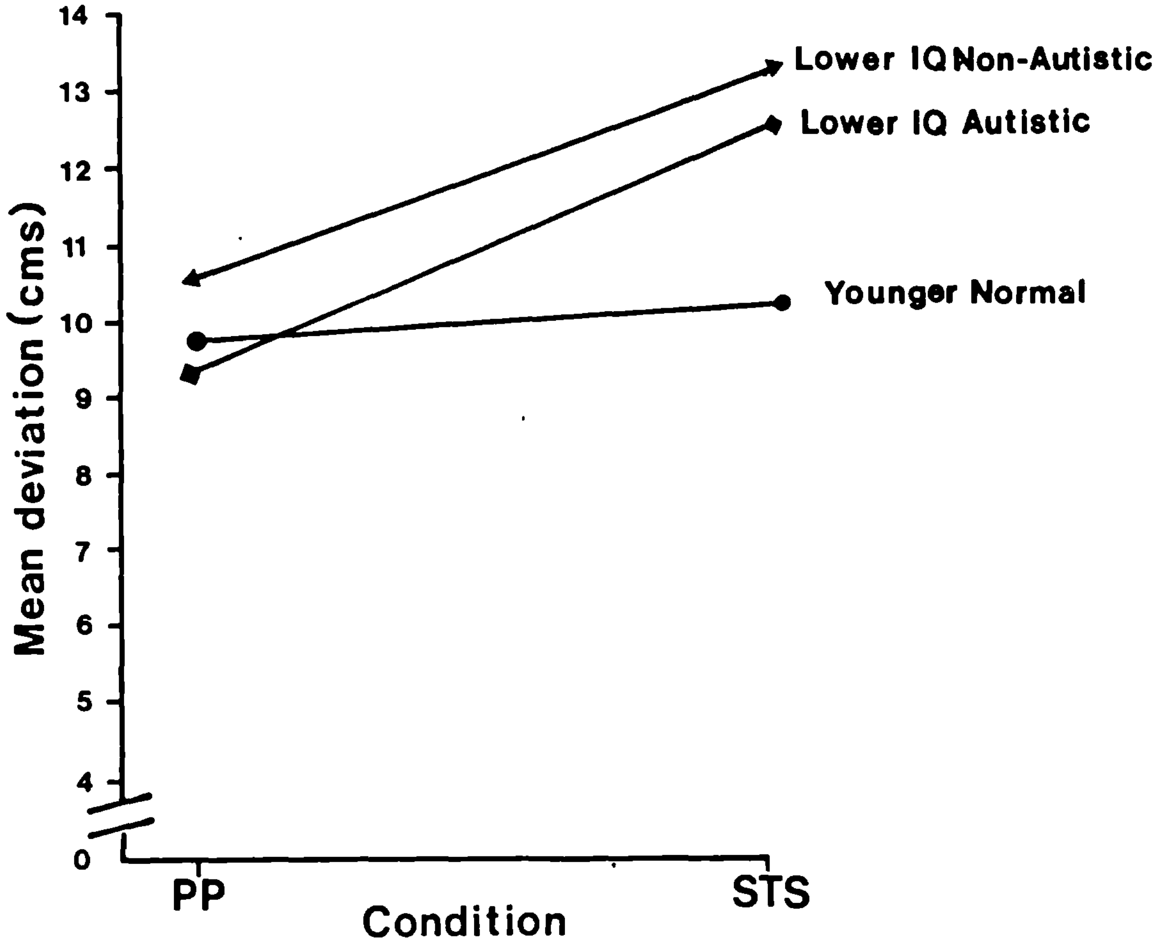
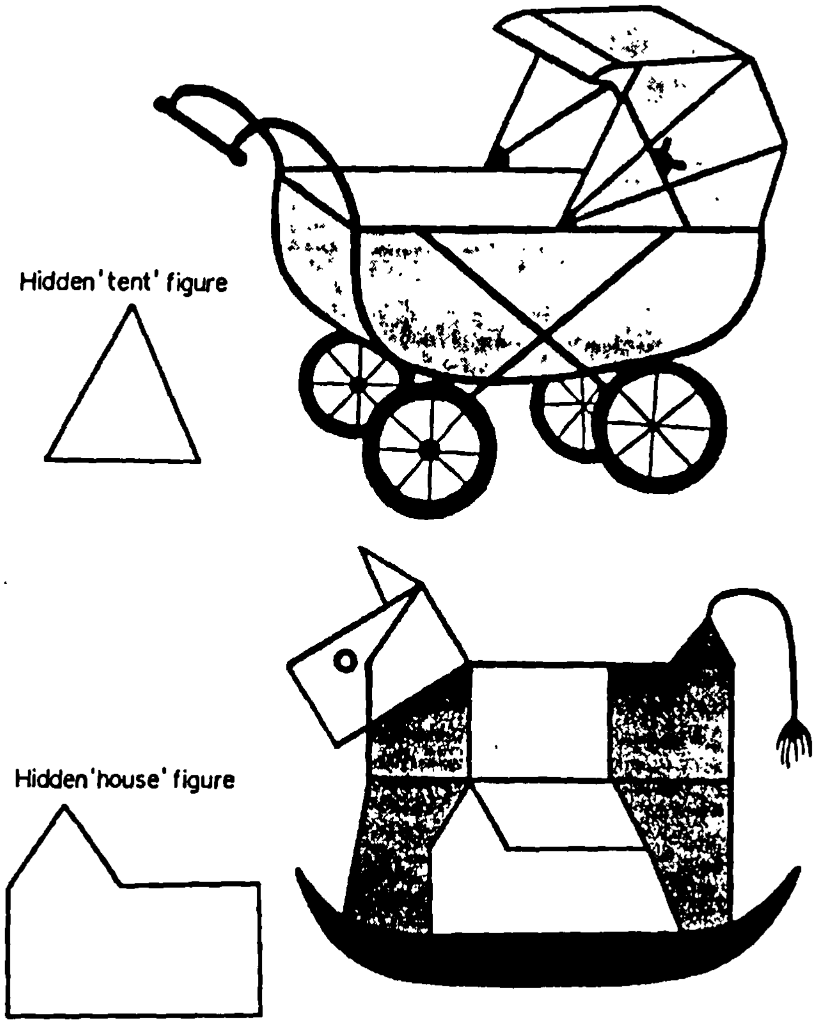


Figure 5.16

EXAMPLES OF ITEMS FROM THE C E F T (WITKIN et al,1971)



5.4.3.2. The effect of incongruent backgrounds including oblique lines

The relevant conditions here were ST and TS where one background consisted of small squares and the other of large triangles. There was no difference between the means of ST and TS for any of the groups . Thus the scores of ST and TS were combined to give an overall mean called STS.

a. Average IQ Autistic and Old Normal

The presence of an incongruent framework with diagonals had the same effect as the incongruent framework without diagonals. There was no significant interaction, but the main effect of condition was significant ($F_{1,24}=10.42; p<.01$). Thus, as can be seen in Figure 5.14 these conditions had a detrimental effect on the performance of both the groups.

b. Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic

Again, no significant interaction was found between group and condition, but the main effect of condition was significant ($F_{1,35}=19.26; p<.001$). Thus these interfering conditions with diagonals deteriorated the performace of all 3 groups. As shown in Figure 5.15, the performance of the Younger normal group was the least affected of the 3 groups.

5.5. Discussion

This experiment compared the two autistic groups and the various control groups on a very basic spatial task, that of remembering position in two-dimensional space. The interest was not so much in comparing overall accuracy levels but in the effects of the various conditions on the basic performance of each group. In particular, the hypothesis that the performance of the autistic groups would not be affected by contextual frameworks was investigated.

On the basic task on which no helpful or interfering frameworks were especially provided, the Average IQ Autistic group performed very similarly to the Older Normal group. The accuracy level of the Lower IQ autistic group was lower than that of the Normal IQ autistic group but very similar to the Younger Normal group and the Lower IQ Non-Autistic group. The mean accuracy scores of all 5 groups on the basic task were in fact within 3 cms. The task was thus neither too difficult nor too easy for any group. This was important as it meant that the effects of the various conditions could be meaningfully compared to this basic task performance for all the groups.

The prediction that the autistic groups would not particularly benefit when helpful framework cues were provided at input and output was not confirmed. In fact, the Average IQ Autistic group benefitted the most from the framework cues provided and performed at a near optimum level on this condition. Their performance on the condition where grids were provided at the input and output stages showed that they were able to use the framework for relative coding even more efficiently than the Older Normal group.

The results of the Lower IQ Autistic group were no different from the Younger Normal and the Lower IQ Non-Autistic control groups. All three groups benefitted from framework cues to a similar extent.

When the grid framework was provided only at input or only at output, the Average IQ Autistic group and the Older Normal group performed similarly and as accurately as they did on the basic task. The other three groups, however, deteriorated in their level of accuracy when the grid frameworks were not available at both input and output. This suggests that the presence of the grid at the input or output stage only became an interference for these three groups. It seems that the Average IQ Autistic and the Older Normal groups were able to disregard the grid and to fall back on their absolute code which was not as efficient as the relative code used when the grid frameworks were available at both input and output. It is interesting that although all the groups had had experience of using a grid framework to aid performance, they were unable to use a strategy of imposing a similar mental grid to code the position more efficiently when the grids were not available at either input or output.

The prediction that the presence of conflicting frameworks at input and output would not affect the performance of the autistic groups was not confirmed. This prediction was based on the hypothetical premise that they would use an absolute code rather than a relative code for remembering position. However, all the results suggest that they use a relative code similar to the control groups. The Average IQ Autistic group was almost as affected by the interfering framework cues as the Older Normal group. Although the Older Normal group was more affected than the Average IQ autistic group, this difference was not significant. For both these groups, the order of the conflicting background did not matter.

The performance of the Lower IQ Autistic group, the Younger Normal group and the Lower IQ Non-Autistic group was similarly affected by the conflicting frameworks at input and output. However, for the Lower IQ Autistic group and the Younger Normal group, the order of the conflicting frameworks did make a difference. In the SR condition where the grid framework was available at the input stage together with the rectangle at the output stage, their performance was not as severely affected as when the two backgrounds were reversed for input and output.

We can only speculate reasons for this difference. One possible explanation is that in the SR condition, a very precise coding was made possible at the input stage when the small squares grid was available. (That this is possible was shown by the high level of accuracy of the groups on the SS condition). The conflicting background at output thus has to interfere with a very precise code and is thus not as damaging. In the reverse condition, the initial coding is not as precise and thus more susceptible to interference. It is interesting to note that for the Lower IQ Non-Autistic group, both the SR and RS conditions are equally damaging to accuracy. This together with their results showing low levels of accuracy on the PS and the SP conditions suggests that the code of this group of subjects is very vulnerable to interference with any kind of incongruence between input and output.

Finally, the prediction that the presence of the oblique lines in the conflicting backgrounds would not affect the performance of the autistic groups as severely as that of the control groups was not confirmed. Interfering frameworks containing oblique lines affected the performance of the Average IQ autistic group to the same extent as that of the Older Normal group. Similarly, the effect of the oblique lines on the performance of the Lower IQ Autistic group was similar to that of the Younger Normal group and the Lower IQ Non-Autistic group. However, this time the order of the conflicting background did not make any difference for any of the groups. This suggests that the oblique has a powerful interfering effect even when the initial coding is presumably quite precise as on the ST condition where the small square grid is available at the input stage.

The most persistent and striking results of this experiment concern the disconfirmation of the hypothesis that the autistic subjects would rely more on an absolute memory and that this would withstand interference from conflicting background cues. Both the autistic groups showed a strong tendency towards remembering position by using the frameworks provided. Also, this method of relative coding was very susceptible to interference by conflicting frameworks. Thus, in this particular task, the framework had a significant effect on the perception and memory abilities of the autistic groups. This is in contrast to their performance on the Children's Embedded Figures Test (CEFT) reported by Shah & Frith (1983). In this study, the autistic group showed superior ability at locating embedded figures which suggested that their perception may not be dominated by the embedding framework. This discrepancy needs an explanation.

It is important to look closely at what the frameworks consist of in the two tasks. As suggested by Shah & Frith (1983), the task of finding simple figures embedded in complex figures consists of resisting the tendency to be overcome by the overall <u>meaning</u> of the complex figure and instead exercise a tendency to perceive the details which make up the whole. The framework in this case is the complex figure which is a caricature of a meaningful figure such as a dog, pram, house, etc (see Figure 5.16 on page 170). In the present task of remembering relative position, the framework consisted of geometric shapes such as squares, rectangles and triangles. These frameworks are of a spatial nature and do not have any meaning. The fact that the autistic groups were affected by such frameworks suggest that it is the meaning of the framework (in the CEFT) which is the crucial feature which they are able to ignore. Thus, frameworks without meaning affect their perception and memory to the same degree as that of the control groups.

5.6. Conclusions

The main conclusions that can be drawn from this experiment are listed below.

1. On basic spatial tasks, autistic people seem to process information in a normal way and do not show any evidence of abnormal cognitive functioning.

2. The theory that autistic people have a tendency to disregard contextual frameworks does not extend to frameworks without meaning.

3. The Average IQ Autistic group maintains the high level of performance on yet another spatial task. On the condition where relative coding is made easy by providing helpful

framework cues, they in fact excel in performance in comparison with a stringently matched normal control group. This provides another example of their super-normal islet of spatial ability.

4. Although the performance of the Lower IQ Autistic group does not reach 'super-normal' levels, their performance throughout is more like the normal IQ control group than the Lower IQ control group. Thus, their performance on a basic spatial task is qualitatively normal.

5. On this basic spatial task, the two autistic groups do not differ in the strategies used although their accuracy in quantitative terms is different.

6. The pattern of performance between the two autistic groups thus remains the same as shown in the IQ test results discussed in the preceding chapter. Both groups are able to achieve at least normal levels of performance on spatial tasks, and the Average IQ group goes one step further and achieves super-normal levels on some spatial tasks.

So where does this take us in our search for explanations regarding the 'islet' of normal and super-normal ability shown by autistic people on some spatial tasks and regarding the possible differences in cognitive functioning between the two autistic groups? First, the results of this experiment suggest that explanations in terms of an abnormal method of cognitive processing (e.g. a tendency to disregard context) may be too general and simplistic. Second, if there are differences in cognitive processing skills between the two autistic groups, these are very subtle and certainly not evident on simple spatial tasks.

It seems that we need to consider more complex visuo-spatial tasks and investigate cognitive processing on the various components of these tasks. In the 1983 paper (Shah & Frith), it was suggested that an additional reason as to why the autistic subjects showed such superior ability at locating embedded figures may be related to the fact that this task does not entail any 'visualization' ability, i.e. the ability to mentally rotate or manipulate the stimulus object. We hypothesized that autistic children may be poor at this 'visualization' component of spatial tasks. Visualization is a very important component in most spatial tasks and thus this hypothesis seems contradictory considering that autistic people seem to excel on most spatial tasks. The next experiment (No.2) investigates the extent and nature of this ability in the two groups of autistic people with a view to finding a plausible explanation for the islets of 'normal' and 'super-normal' ability. It also attempts to compare the groups on more subtle components of complex visuo-spatial tasks by using a paradigm that lends itself to an information-processing analysis.

5.7. Summary of Chapter (5)

In this chapter, the first of the present series of experiments, all of which aim to investigate the question of how autistic people achieve high levels of performance on visuo-spatial tasks, was described. The experiment compared the autistic groups and their respective control groups on the strategies used to remember spatial position, and the resulting accuracy.

The results showed that the autistic groups did not use any unusual strategies. All subjects made use of external frameworks to the same extent as control groups for coding spatial position. There were some differences between the groups in terms of accuracy achieved. The Average IQ Autistic group was the most accurate and performed at the same level as, or (slightly) better than, the Older Normal group. The level of performance of the Lower IQ Autistic group was more similar to that of the Younger Normal group than the Lower IQ Non-Autistic group. It was concluded that on a basic spatial location task, autistic subjects use the same cognitive strategies that normal and mildly mentally handicapped subjects use. Their performance is in line with their general non-verbal IQ and hence does not specifically relate to their islets of spatial ability.

CHAPTER SIX

Experiment 2 - Visualization ability in spatial tasks

6.1. Introduction

This experiment investigates a very important dimension of spatial ability called visualization. This can be defined as the ability to manipulate visual images or, expresssed differently, the ability to imagine what an object will look like when it is rotated in space. This is of immense practical value. We use it constantly when anticipating the consequences of proposed rearrangements of physical objects, for example when negotiating a bulky piece of furniture through a narrow doorway or when turning the car round through a narrow space, etc. Thus, visualizaton is not only an important and necessary component in many spatial tasks but is also more demanding in terms of mental ability. Even at a two dimensional level, rotations, more than any other translations, present a special challenge to the interpretative facilities in the visual cortex because readily extractable visual features like the vertical, horizontal, or oblique orientations of component lines remain invariant under simple translation (moving to another place without changing angle) but not under rotation. The extra mental effort entailed in interpreting rotations was demonstrated as early as 1886 by Ernst Mach (in Mach, 1959). He noted that the recognition of pairs of irregular shapes as identical is much easier when presented in the same orientation. When one of the figures is presented in a different orientation, the recognition of the identity of the forms requires an additional 'intellectual act', i.e. that of turning the figure round mentally.

The spatial ability to manipulate visual images has been considered an important component of intelligence in psychometric theories of intelligence. For example, the ability to reason about spatial relationships among objects was one of the Primary Mental Abilities (PMA) identified by Thurstone (1938). Mental Rotation ability was specifically tested by the Figures Test of the PMA battery. Such paper and pencil tests, however, provided only crude overall measures about accuracy and speed on a spatial item.

It is only recently that spatial abilities have been investigated experimentally using information-processing models and techniques. Before describing the information-processing approach which has been developed for studying visualizaton, evidence regarding visualization ability in autism is reviewed

6.1.1. Visualization ability and autism

Visualization has been defined above as referring to the ability to imagine what an object will look like when it is rotated in space. This requires formation of a mental representation (image) which can be then be manipulated in some way. Visualization has never been thoroughly investigated in its own right in autistic people. However, there is indirect evidence and suggestions in the literature regarding aspects of this skill.

Shah & Frith (1983) found that on the embedded figures task, autistic children rarely used a strategy which would have required manipulation of an internal representation of the 'hidden' shape. In this paper we also commented on the difference in their level of performance on the embedded figures test compared to their block design scores reported in the literature. Autistic children performed above the level expected for their chronological age on the embedded figures test whereas most studies had reported block design performance to be in the average range expected for their chronological age. We explained this discrepancy by suggesting that they were able to perform even better on the CEFT than other spatial tasks because the CEFT did not require the visualization skill. In other words, lack of ability to visualize prevented them performing the block design test at superior levels, even though they had all the other necessary visuo-spatial skills required for very successful performance. However, as discussed in Chapter (4), there are subgroups of autistic people who do attain superior levels of performance on the block design task. This suggests that they may not have any problem with the visualization aspects of the task. Clearly, rather than making indirect inferences we need to test visualization ability, especially in the present two groups of autistic subjects who differ in their ability levels on the block design task.

O'Connor & Hermelin (in Hermelin, 1978) have investigated the ability of autistic children to manipulate internal representations more directly. In one experiment, blindfolded autistic children were compared to blindfolded normal and blind children on two tasks. On the first task, subjects were required to feel a pair of two-dimensional shapes with their hands and state whether they could be fitted together to form a square. The subjects could not actually manipulate the shapes as these were fixed on a board. On some trials, the shapes could only be fitted together after rotating one of the pieces by 180 degrees. On other trials, no rotation was required. On the second task, the subjects were presented with models of hands in various spatial orientations and rotations, and had to decide whether they felt a right or a left hand. The results showed that, in the first task, the blindfolded autistic subjects performed similarly to the blindfolded normal children and the blind children. On the second task, however, the autistic subjects were not as fast or accurate as the normal children. Their performance was similar to that of the blind children.

The authors have explained these results by referring to the different task demands. The first task does not necessarily require a mental rotation of the shape. It is possible to solve the task just as well by using rotation-independent features of the shapes such as corners and curves. That the subjects did not use mental rotation to solve the task is corroborated by the finding that items that required a 180 degree rotation were solved just as fast as items that did not require any rotation (O'Connor & Hermelin, 1975). Normal sighted subjects who were not blindfolded, however, were slower on the rotation items suggesting that they solved the problem by means of a mental rotation. The second task, on the other hand, can only be solved by mentally rotating an image of a hand and then comparing the rotated image with the given model of the hand. There was no possibility of using any other cues, as hands have the same shape whether they are left or right. These findings show that autistic children performed poorly on the task which required mental rotation of an internal representation. On the basis of these and other related findings, Hermelin (1978) has suggested that autistic children may lack the ability to form, evoke and manipulate internal representations of external events. Unfortunately, as these studies were concerned with a more qualitative analysis of the strategies used by different groups rather than with overall levels of intellectual functioning, detailed data about the IQs of the autistic subjects was not provided. The autistic group was very heterogeneous with performance IQs ranging from 40 to 100. The majority of the subjects (personal communication with Dr. Hermelin) were towards the lower end of the range. This means that these autistic subjects were of much lower overall ability than the two groups used in the present study. Thus, it is difficult to draw any conclusions about visualization ability of higher functioning autistic subjects on the basis of the experiments reported by O'Connor and Hermelin.

Hammes & Langdell (1981) made similar suggestions based on a very different experiment which showed that autistic children did not show appropriate anticipatory eye movements when looking at an object which appeared and disappeared behind a screen at various points along a path. Although the authors interpreted this as a deficit in being able to manipulate a stored image of the object, this is questionable as other interpretations of the results are possible. As pointed out by the authors themselves, autistic children may have failed to show the anticipatory eye movements because they lacked 'object permanence' or were unable to anticipate future events in general. The experiment would have been more conclusive if it had incorporated controls for these possibilities. Moreover, eye-movements may not be a reliable measure of anticipatory behaviour in autistic children especially in view of the findings reported by Hermelin & O'Connor (1970) regarding the tendency of autistic children to fixate very briefly on visual stimuli.

An experiment by Hobson (1984) investigating visuo-spatial role taking in autistic children is of some relevance here. In one experiment, subjects were shown a cube with different coloured sides and were asked to state the colours of the cube that would be visible to a doll who was placed such that she had a different view from that of the subject. Eight out of the ten autistic subjects were able to succeed on this task. Hobson has interpreted the results as showing that autistic children are able to recognize another person's visual perspective. Clearly this task requires cognitive abilities in addition to that needed for realizing that the doll would get a different view of the cube. The subject has to work out what sides would be visible to the doll and name them. It is not clear what strategy the subject would use to work out the correct sides visible to the doll. One possiblity is by mentally rotating an image of the cube to 'see' the other sides. However, it would also be possible to use a verbal reasoning method without any mental rotation. The subject could work out the colour of the sides in question by a verbal decoding of the sequence of adjacent sides. If the subjects solved the task by using a mental rotation strategy, this experiment would provide evidence that autistic children were able to visualize, i. e. to manipulate images. The demands of the task, however, are too ambiguous for this conclusion to be made strongly.

To conclude, the evidence regarding visualization ability in autism is mostly indirect and vague. The only direct study (that of O'Connor & Hermelin in Hermelin, 1978) suggests that autistic people may have a problem with visualization. However, this study does not enable us to make any predictions about how different subgroups of autistic people would cope with visualization, especially the higher functioning autistic subjects as used in the present study. On the other hand, there is evidence that at least certain subgroups of autistic people perform at a superior level on visuo-spatial tasks which require visualization ability. Even if visualization skill is not the major requirement to succeed at these tasks, it seems unlikely that a person incapable of visualization would excel in these particular tasks. It is possible, though, that rather than being an all or none phenomenon, it may be that the autistic person finds certain types of mental manipulations difficult or is slower on some rather than being totally incapable. Also, there may be differences in the visualization deficit in different subgroups of autistic people.

The only way to clarify the picture regarding visualization ability in autism is to investigate the ability in defined subgroups of autistic subjects directly by using an information processing approach which enables the isolation and identification of the underlying processes in spatial tasks requiring visualization. The next two experiments attempt this by using a chronometric technique that has been developed by Shepard & Metzler (1971) to time mental processes in tasks requiring mental manipulation. The next section describes the paradigm and a model proposed by these authors that has become a classic in the field. The evidence in support of the model is described in some detail as the present experiments adopt the same line of reasoning and interpretation.

6.1.2. The experimental approach to visualization

Shepard & Metzler (1971) have developed a unique technique for studying visualization experimentally. The basic paradigm is as follows. The subject is shown two figures which are either identical or mirror images. The figures within a pair are presented at different orientations by rotating one figure about its centroid. The subject's task is to indicate whether the two figures are identical (except for rotation) or are mirror images of each other. Shepard & Metzler (1971) and since then many others have found that the reaction time to make a same-different judgement is a linear function of the difference in rotation angle between two figures (Cooper,1975; Cooper & Shepard, 1973a). A typical graph of results so obtained is shown in Figure 6.1.

This basic linear relationship has been obtained with a wide variety of stimulus materials including various types of perspective drawings of three dimensional objects (Metzler & Shepard, 1974), random two-dimensional polygons (Cooper, 1975), and patterns of dots (Corballis & Roldan, 1975). The linear function has also been obtained with various task

Figure 6.1

GRAPH TO SHOW TYPICAL RT/ORIENTATION RELATIONSHIP

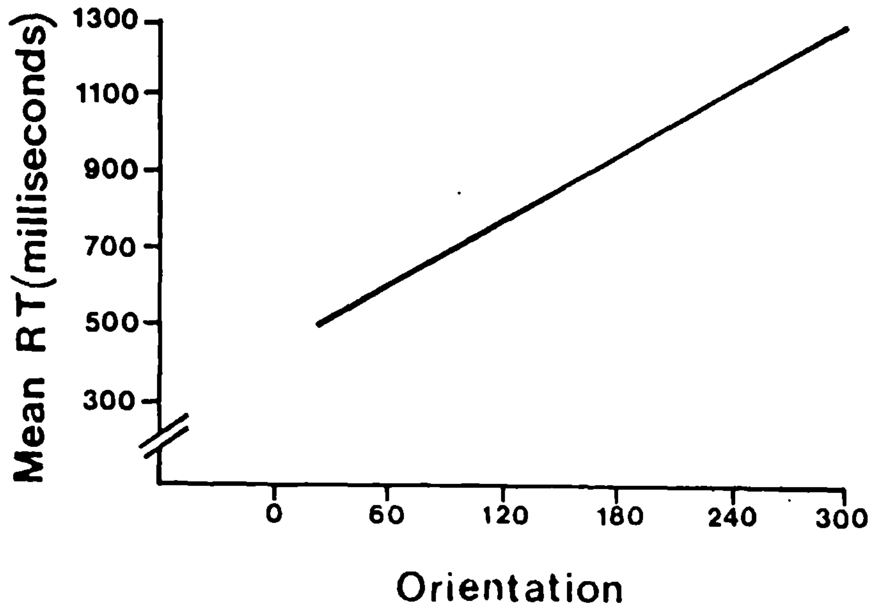
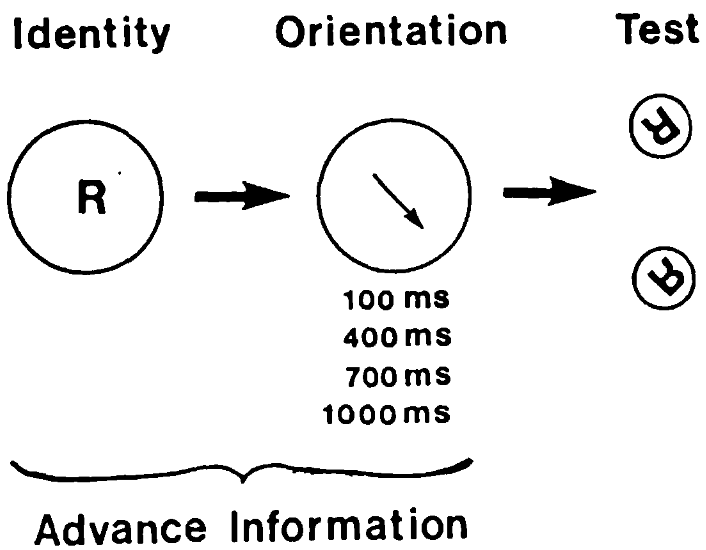


Figure 6.2

SEQUENCE OF VISUAL DISPLAYS IN EXPERIMENT ON ADVANCE INFORMATION (REPRODUCED FROM COOPER AND SHEPARD, 1973)



modifications. For example, when a single rotated pattern must be compared with a pattern in memory (Cooper, 1975), or when rotations must be carried out before a test shape is displayed (Cooper, 1975; Cooper & Podgorny,1976).

The linear RT function is interpreted as indicating that subjects perform the task by 'mentally rotating' an internal representation of an object into congruence with the other and then comparing the two representations for a match or mismatch in shape. The process of mental rotation is conceptualized as an internal analogue of the process that occurs when rotation of an external object is perceived. Four processing stages are involved:-

a. stimulus coding;

b. an analogue mental rotation of the stimuli into congruence;

c. comparison of the analogue representations;

d. a motor response.

These stages are assumed to be serial in order and independent. The encoding, comparing and responding times are unaffected by the rotation angle. Thus, any increase in RT associated with an increase in the angle of rotation is due solely to the additional time needed to visualize a longer rotation. This model implies that the slope of the linear function relating RT to rotation angle measures only the speed of mental rotation (the reciprocal of the slope being a rate measure). The intercept of the RT function represents the composite time needed for encoding, comparison, and response. Experimental results suggest that both the slope and intercept parameters vary according to stimulus type (Cooper & Shepard, 1973b). There are also large individual differences in these suggesting differences in the speed and rate of mental rotation.

6.1.3. Developmental aspects of mental rotation

The age of onset of this ability was investigated by Marmor (1975) by testing 4 and 5 year olds and college students on a simplified mental rotation task. The findings showed that children at such a young age were able to do the mental rotation task and showed the classic linear trend between RT and rotation angle. The main developmental change was the increasing efficiency with which mental rotation was carried out, that is, error rates decreased with age and the speed of mental rotation doubled between the ages of 4 and 5 and increased by more than a factor of 6 between the ages of 4 and 20. Similar developmental changes were reported by Kail et al (1980) who compared the performance of 7-10 year olds and 17-21 year olds.

Studies comparing performance of different groups of adults suggest an age-related slowing down in the speed of rotation (as reflected in steeper slopes) and also of the other processes of encoding, comparing and responding (reflected in increasing intercepts) between the ages of 20 and 60 (Berg et al,1982; Gaylord & Marsh, 1975; Cerella et al,1981).

6.1.4. Experimental evidence for the mental rotation explanation

The linear relationship between RT and angular difference, and subjects' self reports of 'mentally rotating' the stimuli into congruence provide some evidence that the internal process underlying the observed reaction times is an analogue of an external rotation. More direct evidence of this is provided by other experimental studies specifically designed for the purpose. The reasoning behind this set of studies is that if the mental rotation is an analogue process, intermediate stages of the process must have a one to one correspondence to intermediate stages of an actual physical rotation of one object into congruence with the other in the external world. This suggests that there is a path or a trajectory that the process follows. The authors point out that this does not necessarily mean that there is any concrete resemblance or first-order isomorphism between the patterns of activity in the subject's physical brain at a particular point in time and the corresponding external object (if it were present). Nor does it mean that there has been anything actually rotating within the subject's physical brain. Studies providing the evidence are summarized below.

In one study (Shepard, 1973) using alphanumeric characters, subjects had to decide whether a particular test stimulus (e.g. letter R or G or number 2) presented in varying orientation was a normal or backward (mirror-image) version of the character regardless of their orientation in the picture plane. Before each stimulus appeared, subjects were given advance auditory information about the identity and the orientation of the ensuing test stimulus (e.g. the letter R in the 4 o'clock position). The results showed that the function relating RT and orientation of stimulus was flat (almost horizontal). These results are explained as suggesting that the subjects were able to prepare for the presentation of the rotated alphanumeric character by using the advance information to generate a mental image of the character and then to rotate this image into the appropriate orientation. Then , when presented with the actual test stimulus, the subject could make the required discrimination response quite rapidly by comparing the visual test character against the internally generated and pre-rotated mental image.

A subsequent study (Cooper & Shepherd,1973) explored this process in more detail by manipulating both the orientation of the test stimulus and the duration of the advance information concerning the orientation. This time the advance information was presented visually within a circular aperture of a 3-field t-scope. The identity cue was displayed as an outline drawing of the normal upright version of the upcoming test stimulus, and the orientation cue was an arrow pointing in the direction at which the test stimulus would appear. Figure 6.2 (reproduced from Cooper & Shepard, 1973a) shows the sequence of the visual displays. There were 5 different conditions as follows:-

1. no advance information provided;
2. information concerning identity only provided;
3. information concerning orientation only provided;
4. identity and orientation information provided seperately;
5. identity and orientation information presented together.

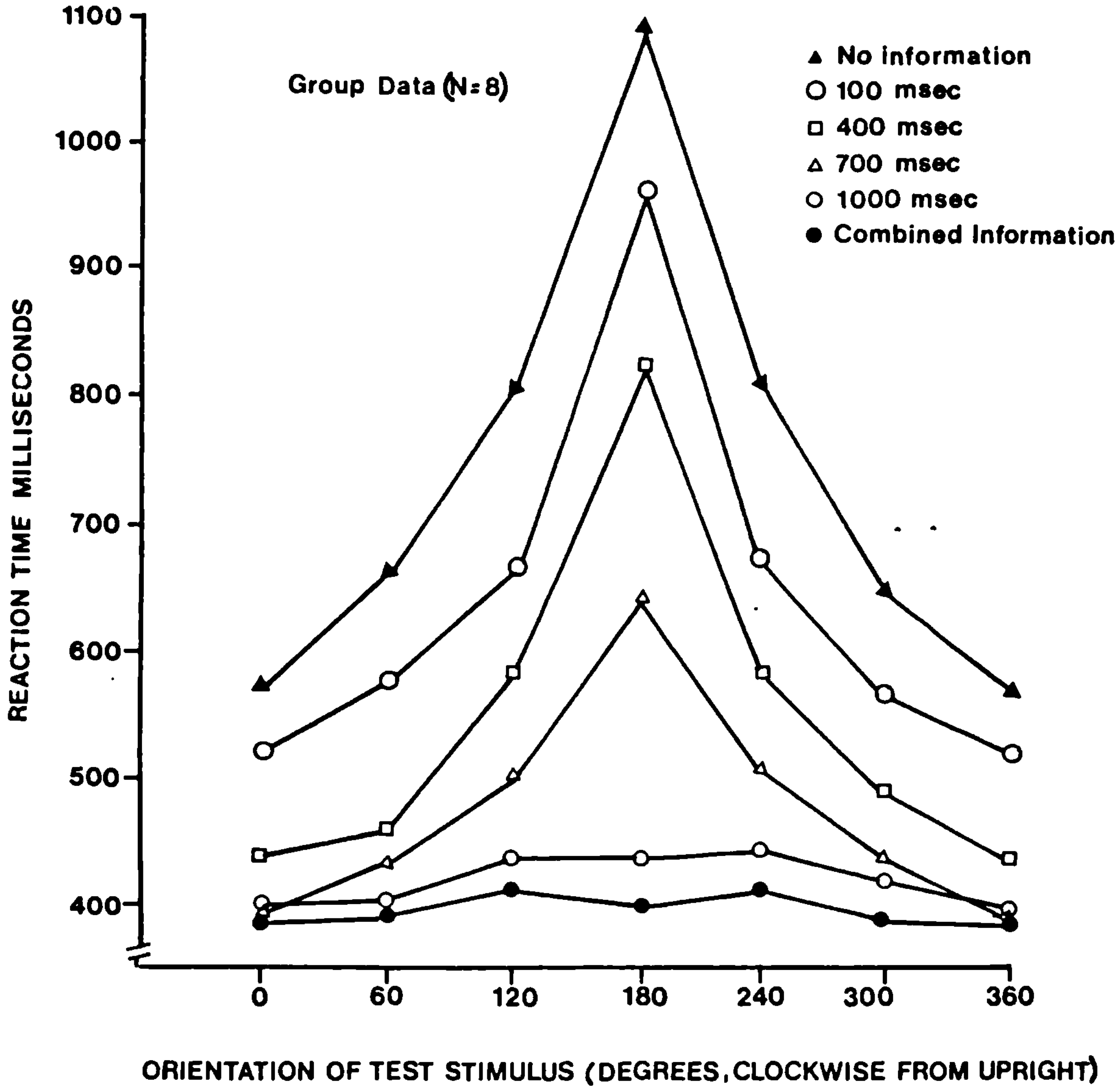
The identity cue was always presented for 2000 msec, but the duration of the orientation cue varied from 100-1000 msec.

The results were as follows. For the conditions with advance information as to identity or orientation only, there was the usual relation between RT and angle of rotation and the shapes of the curves were very similar to the condition

Figure 6.3

RESULTS OF EXPERIMENT ON ADVANCE INFORMATION

(COOPER AND SHEPARD,1973)



in which no information was provided. In contrast, on the condition where both types of information were provided, the function relating RT and angle was unusually flat. The results of the conditions on which the duration of the advance information regarding orientation was varied are shown in the graph in Figure 6.3. At 1000 msec, the function is flat. However, when the duration is reduced to 700 msec, there is a pronounced peak in RT at 180 degrees. When the duration is further reduced to 400 msec and to 100 msec, there is a curvilinear relation between RT and orientation which is similar to that shown when only identity information was provided.

These results suggest that when the subjects have advance information about the identity and orientation of a test stimulus, they are able to construct an internal representation rotated in the necessary orientation and keep it ready as a mental template against which they could rapidly match the test stimulus when it appeared in the same orientation. The results further show that this type of mental rotation cannot be carried out on the basis of just the orientation information alone. The authors interprete this as suggesting that the subjects are not able to rotate a general abstract frame of reference, but only the mental representation of a specific concrete object or character.

In another series of studies, the following basic paradigm was used. Subjects were instructed to imagine a designated visual shape rotating within a circular field (Metzler, 1973; Metzler & Shepard,1974). The subject was trained (prior to the experiment) to imagine a normal version of a character starting in an upright orientation and rotate it clockwise at a rate of 60 degrees per half second in synchrony with the experimenter's auditory commands. At some randomly determined point during the mental rotation, a test probe was presented and the subject was required to determine as rapidly as possible whether the test form was the same as the originally designated shape or its mirror image. On a portion of the trials, the test probe was presented in the "expected" orientation. On the remainder of the trials, the test probe was presented in some other "unexpected" orientation. The points in time during the mental rotation at which test probes were presented were based on estimated rotation rates for each subject. The results were quite clear cut. On the trials where the test shape appeared in the orientation assumed to correspond to the current orientation of the imaginary rotation, RT was short and constant, regardless of the angular departure from the upright. In contrast, when the visual probe appeared in an "unexpected" orientation, RT increased linearly with the angular difference between the expected orientation and the orientation of the test shape.

Similar results were also reported by Cooper (1976) in an experiment in which test probes were presented between the six familiar positions that the subject had learnt to rotate the imaginary character.

6.1.5. Evaluation of the studies

This series of studies provide strong evidence that the internal process underlying comparison of visual objects differing in orientation is essentially one of rotation and that the successive states in the trajectory through which the process passes have a one-to-one correspondence to the successive stages in the rotation of an external object. The theory of mental rotation is able to account for all the empirical findings reported above.

However, alternative explanations to mental rotation have been put forward (e.g. Pylyshyn, 1973; 1979; 1981; Anderson, 1978). It has been suggested that instead of a mental rotation, the solution is arrived at by the following types of strategies:-

a. feature by feature comparison of the two objects to determine whether or not all the corresponding features of the two objects achieve a suitable match;

b. comparison of rotationally invariant structural codes; this would involve generating a code or verbal description about the structural relationships among components of each object that is independent of the orientation that the object is displayed in and then comparing these 2 independently derived codes.

Shepard and Cooper (1982) have convincingly discussed why such alternative explanations are not acceptable. It is beyond the scope of the present thesis to go into this argument in any depth. In brief, the objections relate to the fact that none of these explanations can account for the hard data facts established by the empirical experiments cited above. For example, neither of the above theories can explain the monotonic increase in RT as angle of orientation increases. If the subject is using a feature comparison or a code comparison strategy, the angle of orientation of the test shape should not make any difference to the RT. Such comparisons would be made independently of orientation.

6.1.5.1. Analogue vs. Propositional nature of the rotation

Another ongoing debate concerns the analogue nature of the rotation. Several investigators have challenged this notion (e.g. Palmer,1975; Pylyshyn,1973) and suggested instead that abstract , propositional data structures provide a more satisfactory format for the representation of visual information. These sorts of propositional models suggest that the internal representation of a visual object is rotated piece-by-piece or feature-by-feature. For example, Anderson (1978) and Palmer (1975) have put forward models which suggest that the parts of the stimuli are represented relative to a central axis and the spatial relations between the parts and the axis are updated as the represented orientation is changed.

Such models cannot be refuted on the basis of the linear relationship between RT and orientation as this would be similarly predicted by propositional models. However, such models would also predict that the time required to rotate an internal representation of a visual object should increase with the complexity of the visual object because there would be an increase in the number of features, or nodes or pieces that have to be rotated. Cooper & Podgorny (1976) investigated this thoroughly in an experiment which varied the complexity of the stimuli. They found that complexity did not affect RT for preparation or discrimination. Thus, the analogue nature of the rotation seems more likely and is able to explain all the empirical findings adequately.

6.2. The paradigm and model of interpretation used in the present two experiments on visualization ability

The basic paradigm used to investigate visualization and mental manipulation ability on visuo-spatial tasks was the one used by Shepard & Metzler in all their experiments reviewed above. This paradigm was chosen for the following reasons:-

1. It enables the use of an information processing approach in spatial tasks. This is rare in experimental studies of autism though it has been recommended (O'Connor and Hermelin, 1978);
2. It enables a direct investigation of the strategies used by autistic people in solving two-dimensional spatial tasks;
3. The paradigm can be used to time the underlying mental operations for tasks requiring visualization abilities, thus enabling comparisons of groups on very precise measures;
4. The paradigm has been extremely well researched as reviewed above. By using a task in which all the processes have been identified enables us to avoid the pitfalls of previous studies regarding the interpretation of results. There is no ambiguity about what the task demands are;
5. The paradigm lends itself well to micro-computer presentation. The automated procedure means that a large number of trials can be given smoothly and quickly, thus enabling a reliable estimate of reaction time. This is important for subjects who are known to have problems in cognitive functioning.

The results will be interpreted by adopting the model proposed by Shepard & Metzler described above. It is a rare opportunity in a study of autism to be able to use a cognitive model that has been tested out on the normal population and is backed up substantial evidence.

6.3. Aims and Hypotheses

The general aim of this experiment was to investigate visualization ability in two groups of autistic people. The specific aims were as follows:-

1. to see if the two groups of autistic people used similar strategies as used by controls when solving a visuo-spatial task requiring visualization;
2. to compare the accuracy of the two groups with that of their respective control groups;
3. to compare the autistic groups and the control groups on the time taken for various components of the task.

As there was no firm evidence on which directional hypotheses could be based, null hypotheses predicting no differences between the autistic groups and the control groups were adopted for all the planned comparisons.

6.4. Methods

6.4.1. Subjects

There were 5 groups of subjects, similar to and matched on the same criteria as in the previous experiment. The subjects were mostly the same with a few exceptions due to either unavailability or an inability to understand the requirements of the task. Tables of subject details in Appendices (1) to (4) specify which subjects participated in

Table 6.1.
Subject characteristics in Experiments (2) and (3)

	Average IQ Autistic	Older Normal	Lower IQ Autistic	Younger Normal	Lower IQ Non-Autistic
Chronological Age					
Mean	18.6	16.0	18.4	10.9	17.8
SD	1.4	0.6	3.4	3.2	2.5
N	8	17	7	14	12
Full-Scale IQ					
Mean	85.3	-	63.4	-	73.7
Sd	8.4	-	7.8	-	5.9
N	7		7		11
Non-Verbal IQ					
Mean	100.1	100.5	73.0	105.1	76.3
SD	7.6	6.9	5.4	5.7	5.5
N	7	16	7	14	12
Verbal IQ					
Mean	74.4	-	58.6	-	74.5
SD	13.1	-	9.1	-	8.0
N	7		7		11
Block Design Scaled Score					
Mean	15.3	11.4	9.9	10.9	6.3
SD	2.3	2.0	2.1	1.6	1.9
N	8	17	7	14	12

each group and the reasons for non-participation in this experiment. Table 6.1 gives summary statistics of subject characteristics.

6.4.2. Stimuli

A computer programme using BBC Basic language was written to generate the stimuli. The procedure of generating stimuli was modified from Palmer's (1977) system for generating two-dimensional line drawings. A 5 x 5 dot matrix was used and the figures were generated by connecting points specified by a data programme. This method of generating figures was used simply because it was possible to obtain geometric shapes of roughly equivalent complexity and their rotated counterparts without the use of sophisticated and expensive graphics programmes.

The stimuli sets thus generated were as follows:-

1. 12 standard shapes as shown in Figure 6.4 The figure was drawn in red with a black baseline to indicate the orientation of the figure. The horizontal black line at the bottom of the figure indicates the upright position of the standard shapes;
2. 12 standard shapes rotated 45 degrees anti-clockwise on a central pivot.
   Note that the black line is now at an angle of 45 degrees from the horizontal;
3. 12 standard shapes rotated 90 degrees;
4. 12 standard shapes rotated 135 degrees;
5. 12 standard shapes rotated 180 degrees.

Each of the above shapes was generated as its mirror-image along the vertical axis. Thus there were 60

Figure 6.4

12 STANDARD SHAPES

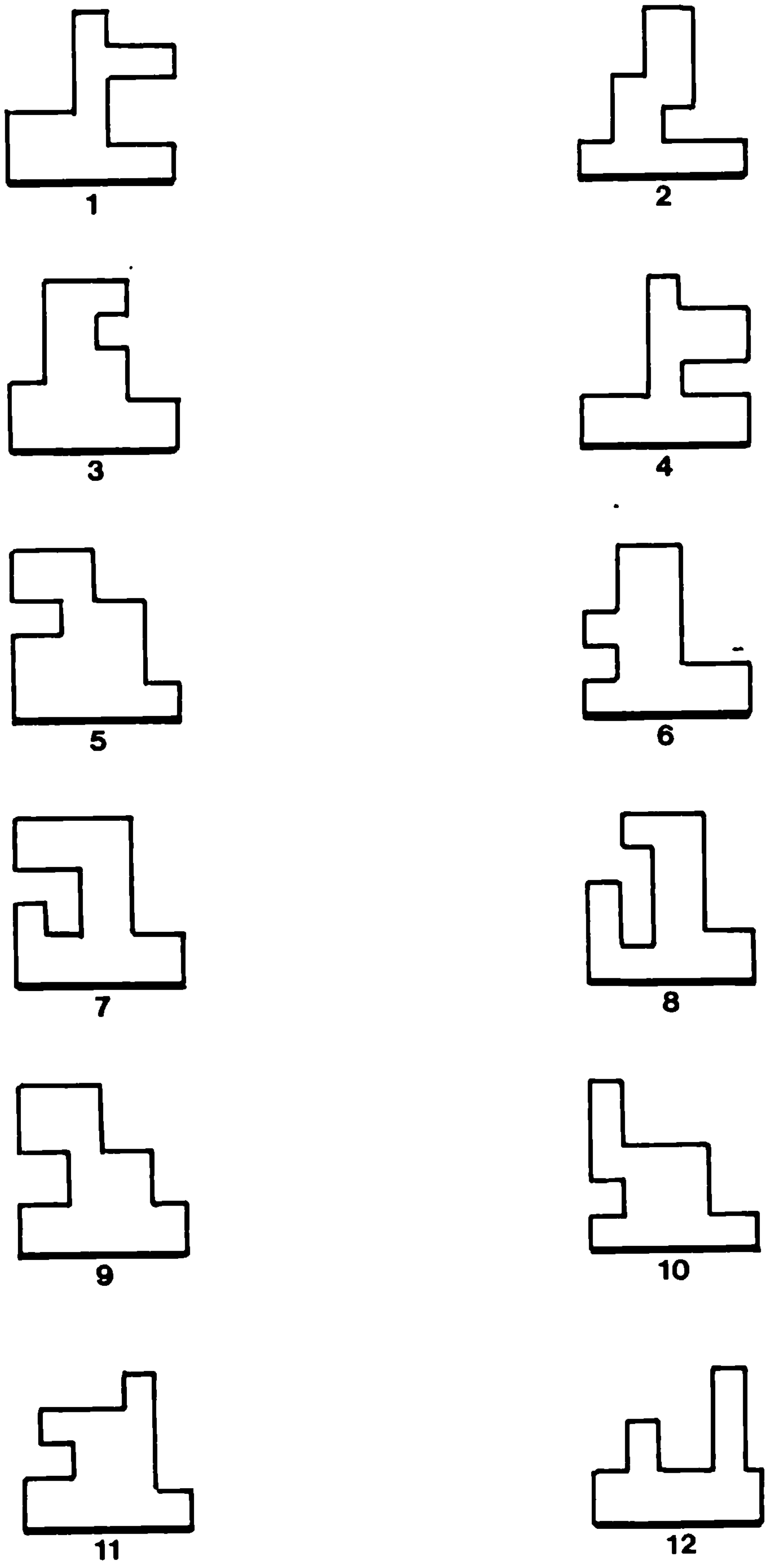
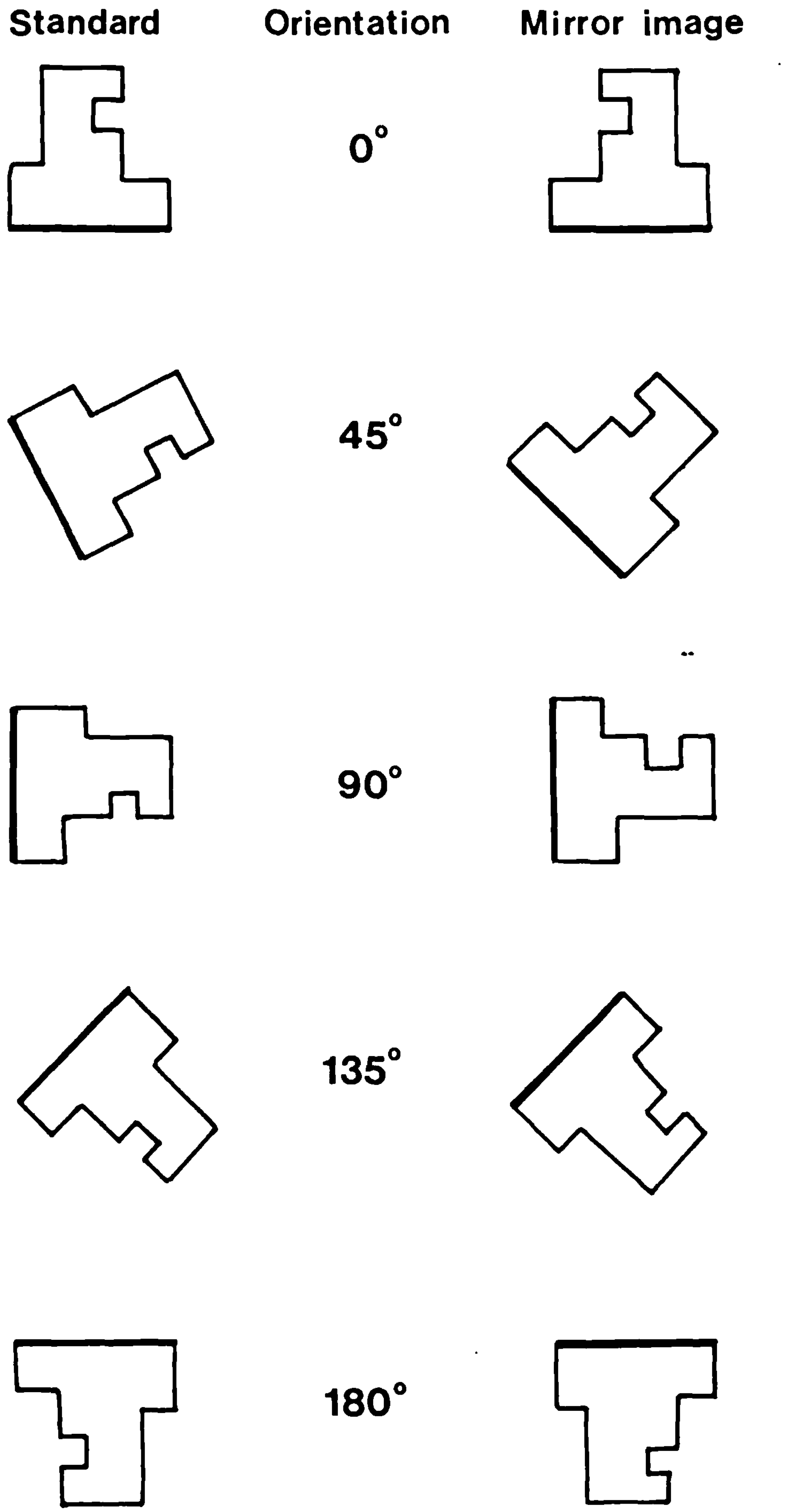


Figure 6.5

EXAMPLE OF A STANDARD SHAPE AND ITS MIRROR IMAGE IN VARIOUS ORIENTATIONS



mirror image shapes as follows:-

1. 12 in the upright orientation;
2. 12 rotated 45 degrees;
3. 12 rotated 90 degrees;
4. 12 rotated 135 degrees;
5. 12 rotated 180 degrees.

The above constituted the entire pool of stimuli from which specific combinations of stimuli were printed as necessary. Figure 6.5 shows a standard shape, its mirror image and each of these in the various orientations.

The basic paradigm

For any trial, two of the above stimuli were presented simultaneously , one centred on the left of the monitor screen and one centred on the right of the screen. The figure on the left was always a standard shape in the upright position. The figure of the right (referred to from now as the comparison figure) was its counterpart in any one orientation (0, 45, 90, 135 or 180 degrees) and either the same as the standard shape or as its mirror image. The subject's task was to verify whether the figure on the right was the same as the standard figure or whether it was the mirror image.

6.4.3. The apparatus

The stimuli were presented using a BBC micro-computer, a colour monitor and a single disc-drive. A special set of two response keys were attached to the BBC . Programmes were written in BBC Basic for each stage of the experiment. These were recorded on magnetic discs. The programmes controlled the presentation of the stimuli, intermittent reinforcement as necessary and the recording of the subject's response and the reaction time in 1/100 of a second.

6.4.4. Procedure

There were 5 distinct stages in the experiment. First, the general procedure which was common to all stages is described followed by the detailed procedure for each stage.

6.4.4.1. General procedure

Each subject was tested individually in a quiet room. Prior to each session, the experimenter (referred to from now as E) set up all the equipment and ensured that everything worked smoothly. The subject then came in and was asked to sit on the chair facing the monitor screen with the response keys in front of him/her. E loaded the programme on the computer and started it. This triggered the following basic sequence.

Two yellow rectangles appeared , one centred on the left of the screen and one centred on the right of the screen. When the subject was ready, E presssed one of the keys which caused two test shapes (a standard shape and a comparison shape) to appear. These were red and black line drawings superimposed on the centre of each yellow rectangle. At the same time, the timer in the computer started. The subject then pressed one of the response keys, the right key if he/she thought the comparison figure was the same as the standard figure and the left key it he/she thought it was different, i.e. a mirror image of the standard. Pressing of either key caused the timer to stop. The subject's response and the time elapsed between the appearance of the test shapes and the response were recorded on the magnetic disc.

The display stayed on for 10 seconds regardless of the subject's response. At the end of 10 seconds, the shapes dissappeared leaving the two yellow rectangles on the screen. After 20 seconds, the next pair of line drawings appeared. This sequence repeated itself until all the shapes for that particular stage of the experiment had appeared.

Thus, the whole procedure was automated. E observed the subject and took notes on behaviour during the testing. E did not interfere with the procedure but ensured that the subject was concentrating and was not getting too tired or responding randomly. This was quite important as there were a lot of stimuli to be presented in a monotonous way.

6.4.4.2. Stage 1 - Training and familiarization

The purpose of this stage was to familiarize the subject with the apparatus and to train him/her in the basic requirements of discriminating between two shapes and pressing the relevant key as quickly as possible.

At the start, E instructed the subject to look at the screen and focus on the yellow rectangles. E then started the programme. The first pair of shapes appeared. These were identical to one another. E asked the subject orally whether the shapes were the same or different. When the subject replied , he/she was trained in using the relevant key to indicate the response, i.e. to press the key on the right if he/she thought the shapes were the same and the key on the left if he/she thought the shapes were different. If the response was correct , the following message appeared on the screen together with a pleasant tune:

"Well done - you are absolutely right"

If the response was not correct, the message was "Try again". E then intervened and explained why the subject's response was not correct and pointed out that the shapes were quite different from one another. The same shapes reappeared until the subject responded correctly. This procedure was repeated for 16 pairs of shapes, 8 of which were mirror images and 8 of which were identical. The shapes presented initially were quite simple and the complexity was increased gradually so that towards the end, the shapes were very similar to the test shapes. This training phase was repeated until E felt that the subject understood the mirror-image discrimination and responded as quickly and accurately as possible.

6.4.4.3. Stage 2 - Criterion Test

The purpose of this stage was to test the ability of the subject to discriminate between same and different (mirror-image) pairs in the upright orientation. Equal numbers of same and different pairs were displayed in a random order. The subject was not given any feedback after each trial. The first 10 pairs of stimuli were presented, one after the other in turn, regardless of the subject's response. If the subject responded correctly on all 10 items the display switched off and the following message came on with a pleasant tune:

"Well done - All your answers were correct"

The test was then terminated. However, if the subject responded wrongly on any of the first 10 trials, there was no message and 14 more pairs of stimuli were presented. If the subject responded correctly on least 20 out of 24 trials, a "well done " message appeared. If the subject responded incorrectly on more than 4 out of the 24 trials, the test was terminated and there was no message. Thus, the criterion was responding correctly on all of the first 10 trials or on at least any 20 of the 24 total trials.

Subjects who passed the criterion test went on to the next stage of the experiment.

6.4.4.4. Stage 3 - Training in discriminating tilted figures

In this phase, the comparison shape was presented in a tilted version. E pointed out to the subject that he/she was required to make the same discrimination between same and different as before regardless of the orientation of the test stimuli. The first pair of stimuli was presented with the comparison figure the same as the standard figure but rotated 45 degrees. After the subject responded, another comparison figure was superimposd in a dotted line on the original so that the subject could see what it would look like in the upright position. This procedure was repeated for each of the 4 different rotation angles and for same and different pairs until E felt certain that the subject had understood what was required. The E also explained about the black line being the base of the figure. The subjects were also told that the comparison figure would always be tilted in an anti-clockwise direction.

6.4.4.5. Stage 4 - Learning Trials

The purpose of this phase was to give practice to the subject at discriminating between same and different for comparison figures in the different orientations. Pairs of stimuli were presented following the general procedure outlined above. There were 44 trials. For each trial, the standard figure was always in the upright position. The comparison figure for each trial was as shown below.

Trial No.	orientation	same or mirror-image(MI)*
1-4	Upright	2 same, 2 MI
5-14	45 deg	5 same, 5 MI
15-24	90 deg	5 same, 5 MI
25-34	135 deg	5 same, 5 MI
35-44	180 deg	5 same, 5 MI

*Within each block of trials, the same and mirror image comparison figures were presented randomly. The 5 standard shapes and their rotated and mirror-image counterparts were drawn from the initial pool described earlier.

This design meant that the subject got blocked practice at each of the different orientation in turn. Also, the tilt angle and hence the level of difficulty increased gradually. For each trial, the subject's response and the RT was recorded automatically on the magnetic disc.

6.4.4.6. Stage 5 - The test trials

Again the general procedure of presenting same and different pairs of stimuli was followed. Subjects were given 50 trials, 5 same and 5 mirror-images at each of the 5 orientations (0,45,90,135,180 deg.). All the 50 trials were randomly ordered with the following restrictions that:
a. a given orientation was not presented consecutively; and
b. same or different pairs were never presented more than 3 times consecutively. The 5 standard shapes and their tilted and mirror-image counterparts were taken from the original pool of stimuli. These were different from the 5 shapes used

in the learning trials. As before, the subject's response and RT were recorded for each trial.

6.5. Results

6.5.1. Accuracy

For each subject, the total number of trials on which responses were correct were calculated for each orientation angle for each of the two sets of trials, i.e. trial when the pairs of stimuli were the same and when the pairs were different (mirror-images). The percentage of correct responses for each group for each orientation are given in Tables 6.2 and 6.3.

As can be seen from Tables 6.2 and 6.3, the accuracy levels for all the groups for the 'same' trials is extremely high, being over 90% mostly and never falling below 83%. For the 'different' trials, accuracy for all groups remains at this high level except for the Lower IQ non-autistic group. The accuracy for this group for 180 degree tilted different figures falls to 70%. This is still very reasonable but does suggest that this group had particular difficulty with these 'inverted' figures.

Interestingly, when the test figure was not tilted at all, the Average IQ Autistic, the Lower IQ Autistic and the Lower IQ Non-Autistic groups did not make any errors at all, but both the normal groups did. This may reflect the tendency for the normal groups to trade speed for accuracy on the very easy items or carelessness on the seemingly easy items.

The important point regarding error rates is that for the 'same' trials on which the reaction time analysis is

Table 6.2.
Percentage correct responses on 'same' trials (Shapes)

	Average IQ Autistic	Older Normal	Lower IQ Autistic	Younger Normal	Lower IQ Non-Autistic
N	8	17	7	14	12
Angle					
0deg	100	96	100	98	100
45deg	100	100	94	98	97
90deg	95	98	97	98	93
135deg	98	100	97	98	91
180deg	90	93	94	98	83

Table 6.3.
Percentage correct responses on 'different' trials (Shapes)

	Average IQ Autistic	Older Normal	Lower IQ Autistic	Younger Normal	Lower IQ Non-Autistic
N	8	17	7	14	12
Angle					
0deg	100	94	97	98	95
45deg	98	95	94	100	92
90deg	98	96	94	100	83
135deg	95	93	91	98	82
180deg	90	90	83	90	70

based, the accuracy level is very high. This is important to establish for a task which could prove difficult for some of the subject groups. The task was not too difficult for any of the groups. Thus, we can be confident that the reaction times are not based on guesses but genuine attempts to deduce the correct solution.

6.5.2. Reaction Time Analysis

The following analysis of the reaction time data is based on trials where the pairs of stimuli were the 'same'. Trials on which pairs were mirror-images, i.e. 'different' were included basically as catch trials and thus are not relevant. Also, as shown in other studies of reaction time 'different' jugdements require greater time than 'same' judgements as they involve additional processing. Therefore, inclusion of the RT data on different trials would have added unnecessary sources of variance into the analysis.

As in Experiment 1,a separate analysis was carried out for each autistic group and its respective control group(s). Thus throughout, the Average IQ Autistic group is compared with the Older Normal group. The Lower IQ Autistic group is compared with the Younger Normal group and the Lower IQ Non-Autistic group.

For each angle of tilt (0, 45, 90, 135, 180 deg), mean response time was calculated from each subject's RT over the correct trials. The group means and standard deviations are shown in Tables 6.4 and 6.5. Individual data for each subject is given in Appendix (14). As in the previous experiment, the raw data were first explored by plotting frequency distributions for each group for each angle. The

TABLE 6.4.
Mean RT (1/100 sec) for Average IQ Autistic and Older Normal groups (Shapes)

	Average IQ Autistic (N=8)		Older Normal (N=7)	
	Mean	(SD)	Mean	(SD)
Angle				
0deg	144	(55)	137	(49)
45deg	247	(92)	171	(40)
90deg	260	(92)	224	(66)
135deg	274	(129)	207	(69)
180deg	317	(122)	253	(101)

TABLE 6.5.
Mean RT (1/100 sec) for Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic groups (Shapes)

	Lower IQ Autistic (N=7)		Younger Normal (N=14)		Lower IQ Non-Autistic (N=12)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Angle						
0deg	195	(34)	154	(58)	216	(115)
45deg	261	(53)	241	(54)	288	(116)
90deg	310	(59)	283	(85)	429	(195)
135deg	311	(117)	284	(139)	434	(236)
180deg	431	(120)	300	(64)	562	(349)

majority of the distributions in each group were normal. The standard deviations revealed that there was a lack of homogeneity of variance across the different angles. However, transformation of the data was not considered necessary as the multivariate procedures to be used in the analysis of variance do not assume an underlying homogeneity of variance (Hand and Taylor, 1987). These procedures, however, do assume normal distribution of the data. The present data met this criterion satisfactorily (Hand, personal communication.)

6.5.2.1. Trend Analysis of the RT data

To compare the groups on RT and to evaluate the effect of the angle of tilt for the different groups , a repeated measures MANOVA (Hand and Taylor, 1987) was computed on the data using an orthogonal trend analysis.

a. <u>Average IQ Autistic and Older Normal group - The</u> group mean RTs for each angle of tilt are plotted in Figure 6.6. There was a significant main effect of angle ($F(4,20) = 17.2741$; $p<.001$) indicating that RT on different angles of tilt were significantly different from each other for both groups. The trend analysis for angle showed a significant linear effect ($F(1,23)=58.83$;$P <.001$). The group by angle interaction just missed significance ($F(4,20)=2.64$;$p<.06$). This suggests that the angle effect was different for each group but this difference did not reach significance. The linear effects for each group can be seen in Figure 6.6. For the Average IQ Autistic group, there is a monotonic increase in RT with increasing angle of orientation. This is true for the Normal IQ group for all the angles of orientation except 135

Figure 6.6

MEAN RT OVER ANGLE OF ORIENTATION: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS (SHAPES)

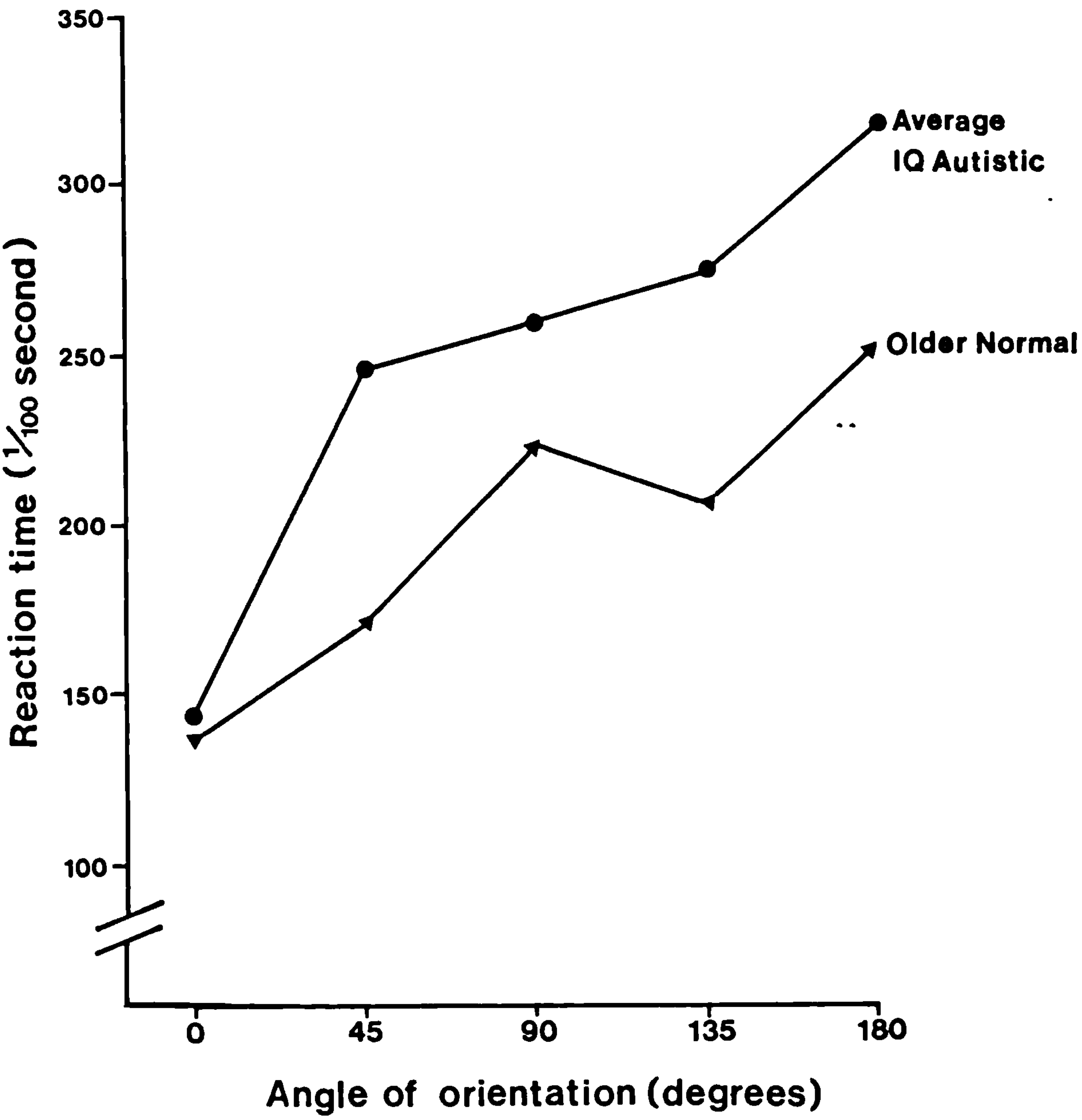
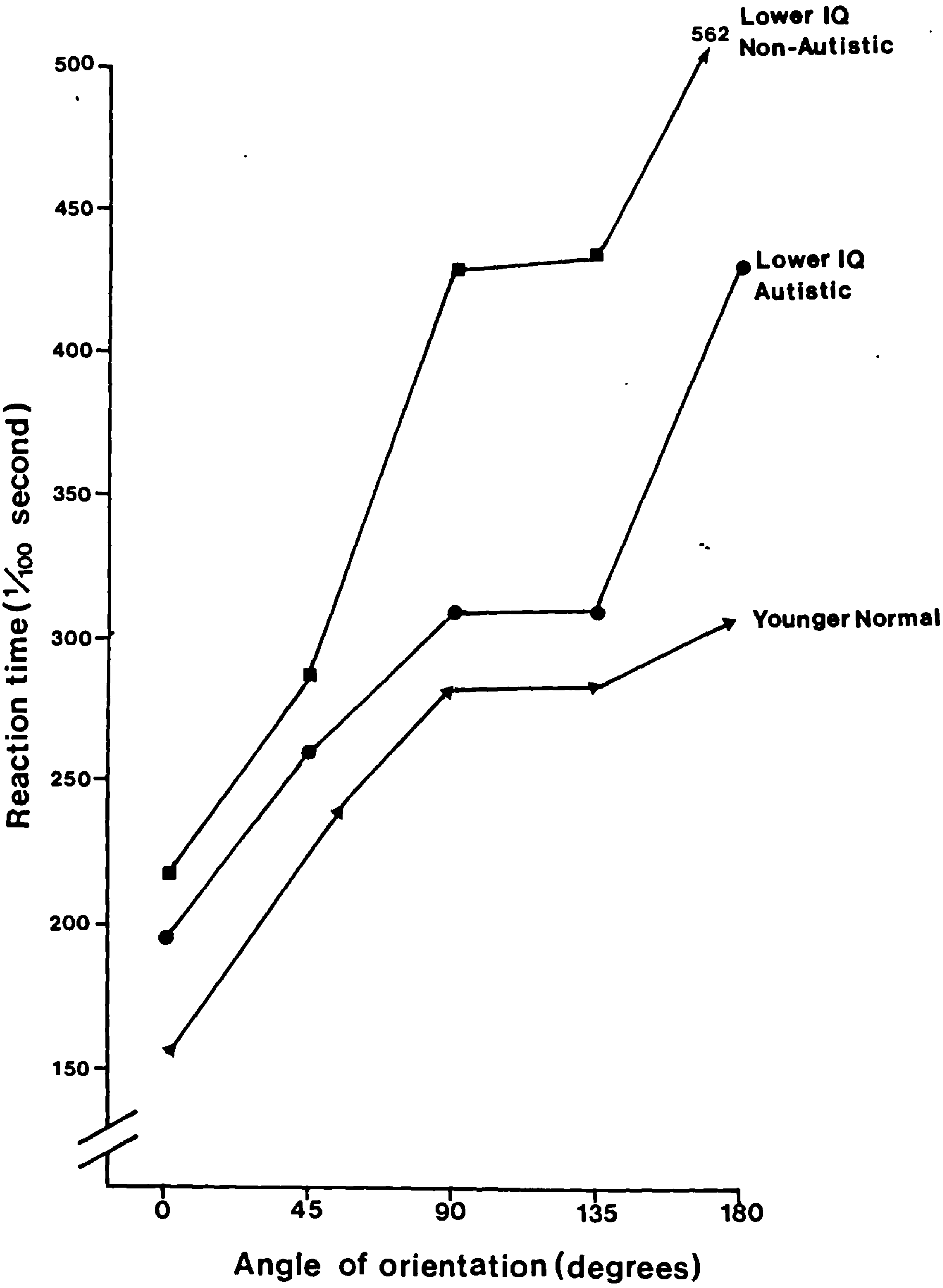


Figure 6.7

MEAN RT OVER ANGLE OF ORIENTATION: LOWER IQ AUTISTIC, YOUNGER NORMAL AND LOWER IQ NON-AUTISTIC GROUPS (SHAPES)



degrees. There is infact a slight decrease in the mean RT on this angle compared to 90 degrees. These results indicate that both groups show an overall linear relationship between RT and angle of tilt, but the slopes relating the two are somewhat different for each group. According to the model adopted here, both groups appear to be solving the visualization task by mentally rotating the stimuli . The slope gives a measure of the speed of rotation. The differences on the slope are analyzed below in more detail.

b. Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic groups

The group means are plotted in Figure 6.7. For these groups, too, there was a significant main effect of angle ($F(4,27)=29.836; p<.001$), and a significant linear trend ($F(1,30)=59.41; p<.001$). The group by angle interaction was not significant. These results indicate that for all the three groups the RT for the various angles were significantly different and that there was a significant linear relationship between RT and angle of tilt for all three groups. The angle effects can be seen clearly in Figure 6.4. All three groups show an overall monotonic increase in RT as angle of orientation increases. All three groups show the least increase in RT between 90 and 135 degrees. The slopes of the three groups appear different. These differences are analyzed in more detail by looking at the linear functions.

6.5.2.2. Further analysis of the RT data

In order to compare the groups on more precise measures, the RT data were further analyzed by looking at the linear function of the best fitting lines for the relation between RT and angle of tilt. This procedure was justified as the linear term on the trend analysis was found to be highly significant for all the groups. Separate slope and intercept estimates were calculated for each subject. Group means are shown in Tables 6.6 and 6.7 together with mean regression values. The latter reflect the goodness of fit of the linear functions. The mean regression values range from .7 to .8 which indicates a strong relationship between RT and the angle of orientation.

The 2 sets of groups were compared on the slope and intercept values.

Slopes: The slope of the function relating RT to degree of rotation provides an estimate of the rate of mental rotation.

a. Average IQ Autistic and Older Normal - The linear functions relating RT and the angle of orientation are plotted for each group in Figure 6.8. The gradients of the slopes of the two groups are strikingly similar although the overall levels are slightly different. The similarity of the slopes was confirmed by a between-group t-test which indicated that the difference on slope was not statistically significant.

The actual speed of mental rotation based on the slope was estimated to be 120 degrees per second or .008 seconds per degree for the Average IQ Autistic group and 157 degrees per second or .006 seconds per degree for the Older Normal group. Thus, the Older Normal group is slightly (37 degrees per second) faster at mentally rotating images of visual shapes. However, this difference is not statistically significant.

TABLE 6.6.
Mean Slopes, Intercepts and Regression:
Average IQ Autistic and Older Normal groups

	Average IQ Autistic (N=8)		Older Normal (N=17)	
	mean	(sd)	mean	(sd)
Slope	.833	(.57)	.637	(.458)
Intercept	173.6	(60.9)	142.7	(39.7)
Regression	.79	(.136)	.8	(.203)

TABLE 6.7.
Mean Slopes, Intercepts and Regression:
Lower IQ Autistic, Younger Normal and
Lower IQ Non-Autistic groups

	(N=7) Lower IQ Autistic		(N=14) Younger Normal		(N=12) Lower IQ Non-Autistic	
	mean	(sd)	mean	(sd)	mean	(sd)
Slope	1.16	(.66)	.741	(.48)	1.95	(1.30)
Intercept	197.1	(38.6)	185.2	(58.5)	134.8	(65.4)
Regression	.8	(.168)	.7	(.223)	.79	(.144)

Figure 6.8

LINEAR FUNCTION RELATING RT AND ANGLE OF ORIENTATION:
AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS
(SHAPES)

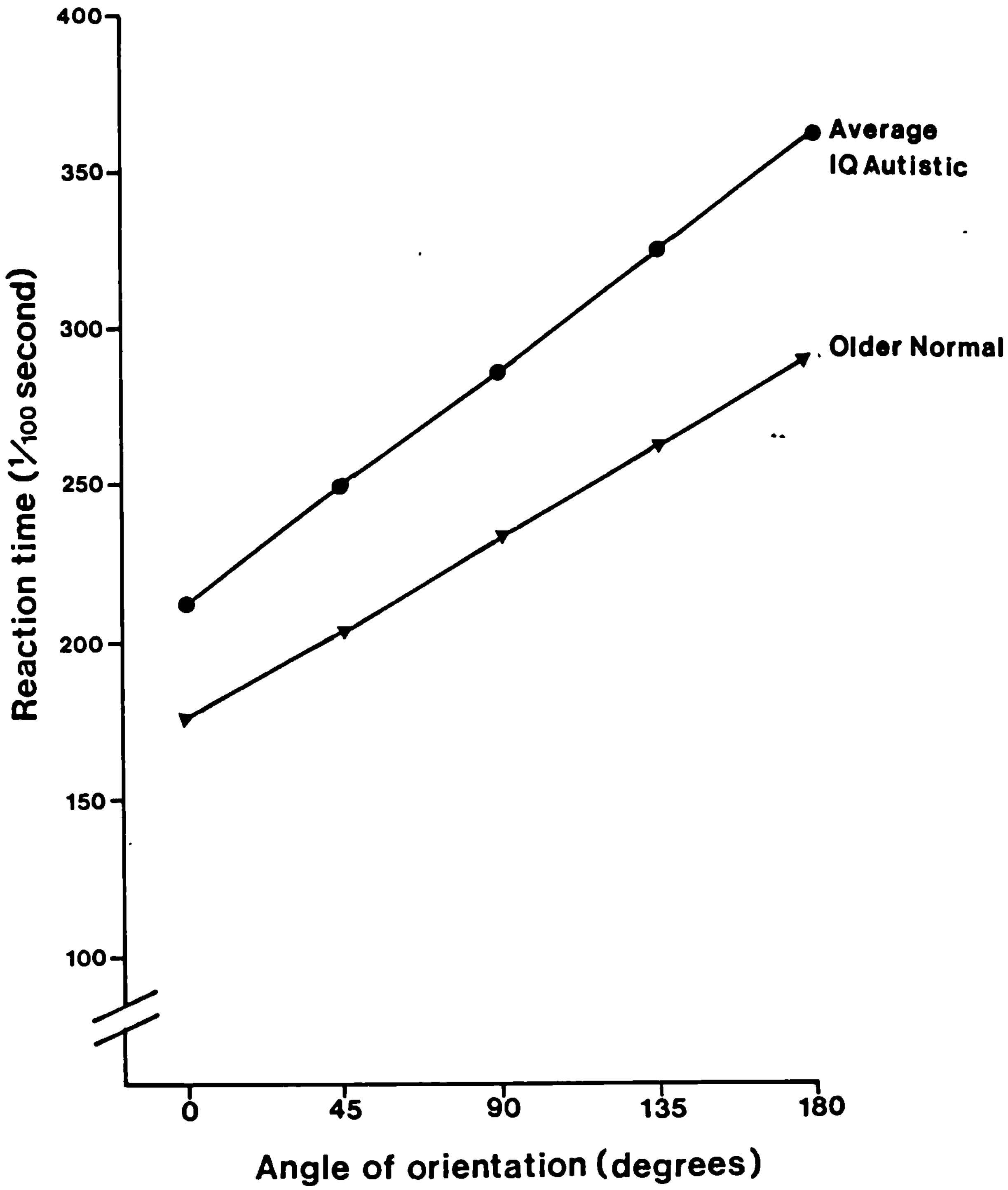
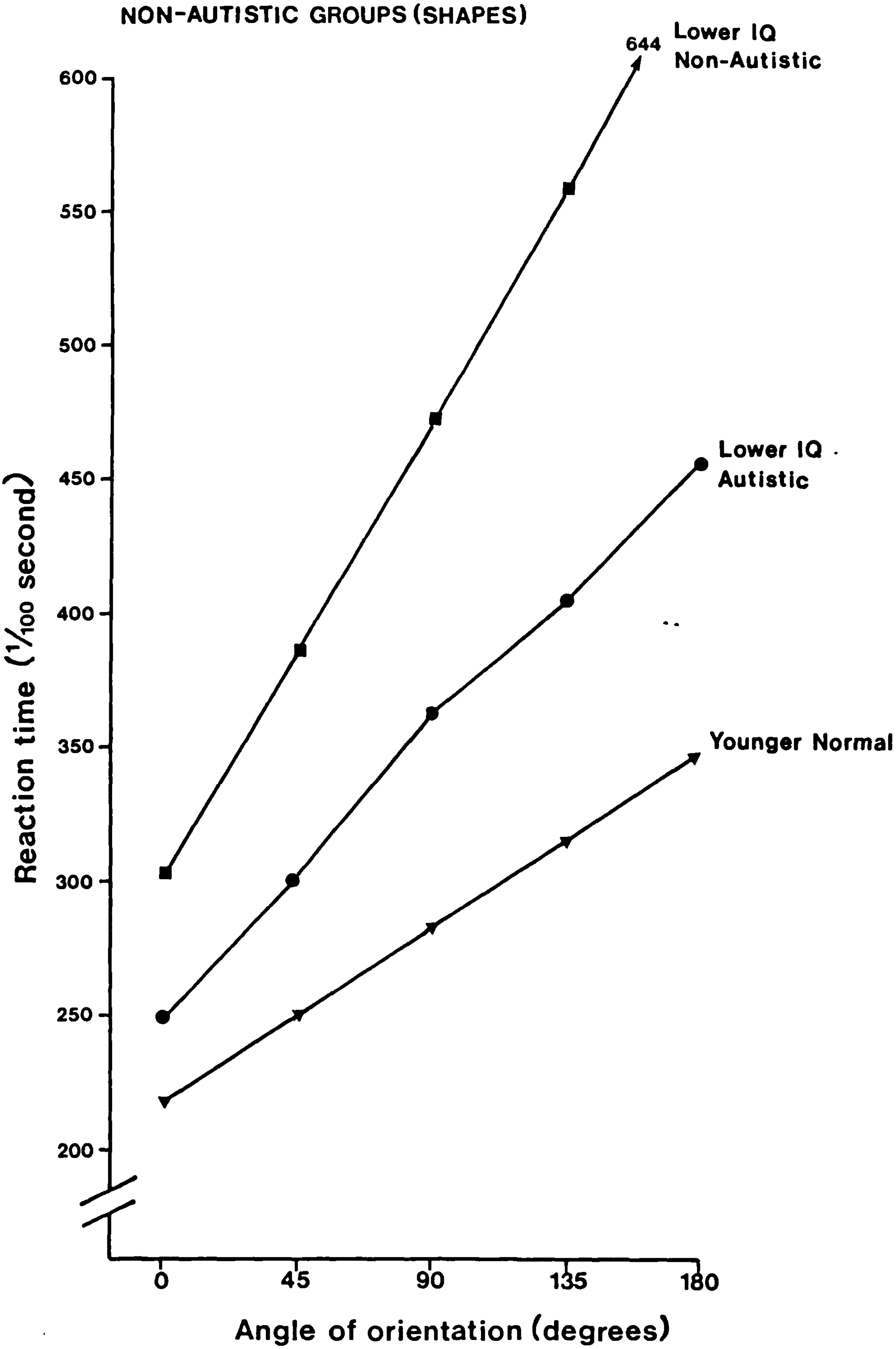


Figure 6.9

LINEAR FUNCTION RELATING RT AND ANGLE OF ORIENTATION LOWER IQ AUTISTIC, YOUNGER NORMAL AND LOWER IQ NON-AUTISTIC GROUPS (SHAPES)



b. <u>Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic groups</u>

The linear function relating RT to the angle of orientation is plotted in Figure 6.9. The differences between the steepness of the three groups can be clearly seen on this figure. These show that the Lower IQ Non-Autistic group rotated the stimuli most slowly, and that the Younger Normal group was the fastest. The Lower IQ Autistic group was in between these two extremes. A one-way ANOVA on the slope values indicated a significant difference between the group means ($F(2,30)=5.888; p<.01$). Post-hoc tests showed that the slope of the Lower IQ Autistic group was significantly shallower than that of the Younger Normal group (SNK and Tukey tests, $p<.05$). However, the Lower IQ Autistic group did not differ significantly from either of the other two groups.

The actual speed of mental rotation based on the slopes were estimated to be as follows:

Lower IQ Autistic - 86 deg per sec or .012 sec per deg
Younger Normal - 135 deg per sec or .007 sec per deg
Lower IQ Non-Autistic - 53 deg per sec or .019 sec per deg

Intercepts: According to Shepard et al.'s model, when the comparison stimulus is not tilted (i.e. at 0 degrees), the RT reflects the time necessary to encode stimuli, compare them and respond. It is better to analyze the estimated intercept from the best fitting lines. Since this is the response latency for 0 degrees rotation, differences between intercepts can be interpreted in the same way as the differences between RT on unrotated pairs. Intercepts have the advantage that they are derived from a much larger data base.

a. Average IQ Autistic and Older Normal - The intercept values of these two groups did not differ significantly according to a between-group t-test.

b. Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic groups

There was a significant difference between the means of these 3 groups ($F(2,30) = 3.477$; $p<.05$). Post-hoc tests indicated that the mean intercept value of the Younger Normal group was significantly lower than that of the Lower IQ Autistic group and the Older Normal group (SNK and Tukey HSD tests, $p<.05$).

6.6. Discussion

This experiment investigated visualization ability in two groups of autistic subjects and their respective control groups using an information-processing model developed by Shepard & Metzler (1971).

The results regarding accuracy levels indicated that the autistic groups were able to perform this demanding visuo-spatial task as accurately as the control groups of normal children. Both groups understood the need to be fast as well as accurate. This is an important finding which shows that it is possible to carry out reaction time studies reliably with autistic people. The successful use of a reaction-time paradigm using micro-computer technology in this study opens up a whole new way of studying cognitive processes in an abnormal group whose cognitive functioning has, in the past, proved notoriously difficult to study.

The results of the reaction times were quite clear-cut. All groups, including the two autistic groups showed a significant and marked linear relationship between reaction-time and the angle of tilt. This corroborates the well established finding in the field , and provides evidence that all groups solved this particular visuo-spatial task by mentally rotating an image of the given 2-dimensional geometric shape. As discussed in the Introduction to this experiment, no other model or interpretation would be able to explain this basic and consistent finding regarding the relationship between RT and angle of orientation of the test stimulus. The set of processes involved in this task can be further specified on the basis of the Shepard and Metzler model. The task can be broken down into the following component skills. First, the subject needs to encode the standard stimulus . Next, this image of the stimulus has to be rotated until its orientation corresponds to that of the comparison figure. The rotated image then has to be compared to the external comparison figure. Another possible method is to encode the comparison figure and rotate it anti-clockwise until it is upright, and then compare the upright image of the comparison figure with the external standard. The model does not predict which of the two figures is encoded and rotated. In any case, the rotations would be of the same duration and therefore there would not be any differences in time between the two methods. It is possible that there may be individual preferences regarding which figure is encoded and rotated.

The detailed analysis of the linear functions showed that the Average IQ Autistic group was not significantly different from the Older Normal group on any of the component processes of this task. Both groups encoded, compared and responded at the same rate. Moreover, both groups were very similar on the estimated speed of the mental rotation. These results show unequivocally that on a visualization task involving unfamiliar geometric shapes, the performance of the Average IQ Autistic group is qualitatively and quantitatively equivalent to that of the Older Normal group. Both groups use the same strategies and perform mental operations at the same rate.

The Lower IQ Autistic group, too, showed evidence of using a mental rotation strategy to solve the task. Thus, their qualitative performance was similar to that of the Younger Normal group and the Lower IQ Non-Autistic group, but there were interesting differences in the rate of the component mental operations. The Lower IQ Autistic group was slower on the encoding and comparing components of the task than the Younger Normal group. Infact, their rate of performance on these processes was similar to that of the control group of Lower IQ Non-Autistic subjects. The differences on the estimated speed of the mental rotation component was less clear-cut. The Lower IQ Autistic group was somewhat slower than the Younger Normal group but not as slow as the Lower IQ Autistic group. However, their rates were not significantly different from those of either control group on statistical tests. An examination of the actual estimates of the speed of rotation shows that rate of rotation of the Lower IQ Autistic group is closer to that of the Lower IQ Non-Autistic group than that of the Younger Normal group.

The Lower IQ Non-Autistic group performed differently from the Younger Normal group on all aspects of the task. They were significantly slower on encoding and comparison components, and also on the mental rotation process. The RT and the accuracy data of this group showed that they found the task the hardest and were particularly thrown by the 180 degrees orientation. Nonetheless, it is clear from the data regarding the relationship between RT and angle of orientation that this group, too, solved this task by using the strategy of mental rotation.

The results regarding the speed of the various processes cannot be directly compared to any previous studies in the field because of the differences in stimulus material used and the procedure. For example, in all their studies, Shepard & Metzler asked their subjects to memorize the image of the standard shape. On the test trials, their subjects have not been presented with a standard shape together with a comparison shape. However, a study by Kail et al (1980) investigating developmental changes in mental rotation did use a procedure similar to that used in the present study although their stimuli were different and consisted of nonsense line drawings from the spatial test of the Primary Mental Abilities. These authors reported mental rotation speeds of .008 seconds per degree for normal 9-10 year old pupils and .005 seconds per degree for 18-25 year old college students. These rates are very similar to the rates of .007 and .006 found in the present study for the Younger and Older Normal groups respectively. The rate of rotation for the Average IQ Autistic group was in the same region (.008 per degree). This level of correspondence between measures which depend on milliseconds adds substantial weight to the argument that these type of visualization tasks are solved by using a mental rotation process which can be timed reliably and accurately. The fact that the rate of the Average IQ Autistic group was also in the same region provides additional corroboration for the normality of the mental strategies used by this group in solving the task.

One interesting but puzzling finding of the present study concerned the RT at 135 degree orientation. The mean RTs indicated that all the groups except the Average IQ Autistic group performed this rotation as quickly as or quicker than the 90 degree rotation. This has not been reported in other studies. It is difficult to find a plausible reason for this finding. It may be some artefact related to the stimulus material used, but that still does not explain why the Average IQ Autistic group did not show this effect.

The overall results of the present study show that both the autistic groups are able to use visualization strategy very efficiently. This contradicts the suggestion made previously (Shah & Frith, 1983)that lack of visualization ability was a contributory factor to their excellent performance on the embedded figures test. On the basis of the evidence presented here, it has to be concluded that their performance on the CEFT must be due to a) the tendencyto ignore the overall meaningful context and b) good overall spatial ability.

The finding that autistic subjects show intact visualization ability is also contradictory to the finding reported by O'Connor & Hermelin (in Hermelin,1978). As described in the introduction, these authors reported that autistic children performed very poorly on a similar task which required visualization ability. The most obvious difference between the two studies relates to the intellectual level of the autistic groups. The present findings suggest that the higher functioning autistic subjects do not have any problem with visualization whereas the study by O'Connor and Hermelin suggests that autistic subjects with even lower levels of IQ than that of the Lower IQ group of the present study find visualization very difficult. The discrepancy between the two sets of findings can be further resolved by examining the tasks used in each study.

The task used by O'Connor & Hermelin was also one based on the Shepard & Metzler paradigm but was different from the present task. In their study, subjects had to determine whether a given model of a hand was a left hand or a right hand. The standard form (left or right hand) was not actually shown to the subjects so the subjects had to make the comparison with a stored representation of a hand in memory. This is different from the present study in which the standard figure was shown together with the comparison figure. Thus, the subject was not required to evoke a memory of a stored representation, but could make the comparison with the externally provided figure. This is an important difference. The two findings taken together ,then, suggest that autistic people are able to visualize images of recently encoded stimuli, but are not able to visualize or manipulate images stored in long term memory. One problem with the study of O'Connor & Hermelin is that it is difficult to resolve from their design whether the autistic children were unable to manipulate an image of a hand or did not have a proper representation of a left and a right hand in memory. An additional problem may have been a difficulty in evoking the image even if it was present in long term memory. In order to confirm unambiguously whether or not autistic people are able to manipulate images stored in long term memory, we need to use a task that involves manipulation of images of familiar and well-learned material. This would overcome the confounding problem of memory and retrieval in this question of mental manipulation. In any case, it is worth establishing whether the finding of the present study, that both groups show an intact ability to visualize, extends to tasks which require visualization of representations from long term memory. This is the aim of the next experiment (No. 3).

Experiment 3 - Visualization of alpha-numeric stimuli

6.7. Introduction

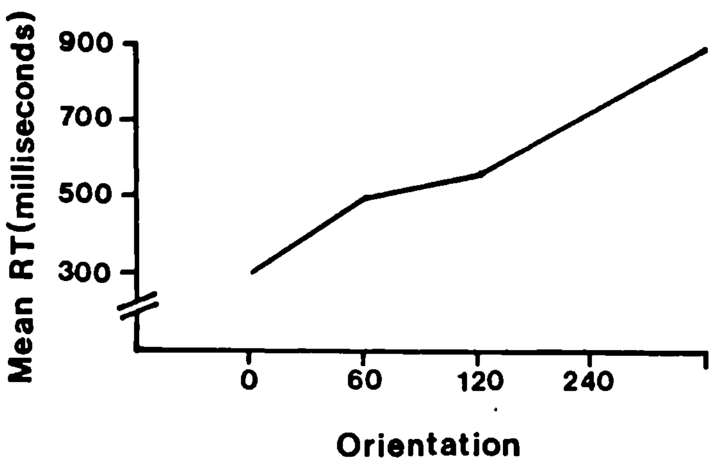
The previous experiment demonstrated conclusively that autistic subjects of average and lower performance IQ were able to use a strategy of visualization which required rotation of visual images of unfamiliar stimuli. Such unfamiliar stimuli do not have a representation in long term memory and thus the comparison stimulus has to be compared with a representation of the standard shape which is encoded in the short term memory. The present experiment was designed to see if this finding extended to familiar stimuli which have a representation in long term memory.

It was decided to use alpha-numeric stimuli as these would be familiar and well-learned by the subjects and also because other researchers have tested out Shepard and Metzler's model on these kind of stimuli. Alphanumeric stimuli are familiar and labelable unlike the nonsense shapes used in the last experiment. The subject , thus , does not have to be presented with a standard form. The task therefore becomes one of comparing the test figure to a representation in long term memory.

The effects of using these types of stimuli have been investigated by several authors. For example, in one experiment, Shepard (1973) used 3 upper-case letters (R,J,G) and three arabic numerals (2,5,7). Each of these six characters appeared in each of six equally spaced orientations around the circle (in 60 deg. steps starting from the standard upright position, 0 deg.). The subjects' task, as before, was to discriminate the normal versions of

Figure 6.10

TYPICAL RESULTS OF AN EXPERIMENT USING
ALPHA-NUMERIC STIMULI



the characters from the reflected versions of those same characters regardless of their orientations within the picture plane. The typical results reported from this type of experiment are shown on the graph in Figure 6.10. As can be seen, RT increases very markedly as the orientation of the stimulus departs from its standard upright orientation. The increase is the same for both clockwise and counterclockwise rotations. The interesting point, though, is that the increase in RT is not strictly linear but concaves upwards with the sharpest increase occuring between 120 and 180 deg. tilt. The marked increase in RT, despite having some unlinearity, is taken to suggest that the subject solves the task by mentally rotating the representation of the character in long term memory in congruence with the tilted test figure and then comparing the two. The increase in RT as angle of tilt increases supports this idea as the greater the tilt, the longer it would take to complete the imaginary rotation. The non-linear concave shape of the RT/tilt function is found only with alpha-numeric stimuli. The authors give various explanations for this:-

1. The representation or 'template' for the normal upright character in long-term memory may be broadly tuned so that for the smaller angles of tilt, the subject may be able to make the comparison without any need for mental rotation.

2. It may be that the rate at which an object can be mentally rotated increases with the familiarity of that object, and that letters and numbers are least familiar when viewed in more or less inverted orientations.

3. The operations of determining the identity and/or orientation of the test stimulus (which presumably must be

completed before the rotation can even be started) may themselves increase non-linearly.

At least the first two of these explanations seem very plausible and may indeed explain the different functions obtained for alphanumeric stimuli compared to those obtained for nonsense shapes.

Other experiments using alpha-numeric stimuli which provided evidence in favour of the mental rotation model have been discussed in the introductory sections of the previous experiment. These are relevant here but it is not necessary to discuss them again.

The other important point made in these experiments is that unfamiliar nonsense shapes are generally encoded, compared and rotated more slowly than the alphanumeric characters (Cooper & Shepard, 1973). The greater time to process unfamiliar stimuli may represent additional encoding time and additional time for external comparisons, both of which are necessitated by the fact that the nonsense shapes are not represented in long-term memory.

Kail, Pellegrino & Carter (1980), in their study of developmental changes in mental rotation, found that unfamiliar characters were rotated more slowly than alphanumeric characters by approximately the same amount at each age level. Unfamiliar characters were also encoded and compared more slowly than alphanumeric characters but the difference between the two declined with development.

6.8. Aims and Hypotheses

The aim of this experiment was to see if autistic subjects would be able to manipulate mental representations in a visualization task with alpha-numeric stimuli. The hypotheses regarding the autistic subjects' performance on this task were based on the evidence that they have difficulty evoking and manipulating representations in long term memory. The specific hypotheses were as follows:-

1. Neither group of autistic subjects would show the classic relationship between RT and angle of orientation;
2. Both groups of autistic subjects would be less accurate and slower on all components of this task than their respective control groups;
3. Both groups of autistic subjects would be slower on this task than they were on the previous task which used unfamiliar shapes as stimuli;
4. All three control groups would show the classic linear relationship between RT and angle of orientation, and they would be faster on all component processes of this task than they were on similar processes in the task than they were on similar processes in the previous task using unfamiliar shapes;
5. It was not possible to make a firm prediction about whether the autistic groups would also be faster on this task.

6.9. Methods

6.9.1. Subjects

The subjects were the same as those in the last experiment (see Table 6.1).

6.9.2. Stimuli and Apparatus

The stimuli were asymetrical alphabetic characters.

There were five uppercase letters (R,G,J,F,P). Each of these were prepared in 5 different orientations (0, 45, 90, 135 and 180 degrees). A computer programme using 'Basic' language was written to generate the characters in standard and reflected versions on the BBC micro-computer. The 10 possible variations are illustrated for the letter 'R' in Figure 6.11. The entire stimulus set thus constituted 50 items.

Apparatus

This was the same as in the previous experiment.

6.9.3. Procedure

There were two stages of the experiment.

Stage 1. Training

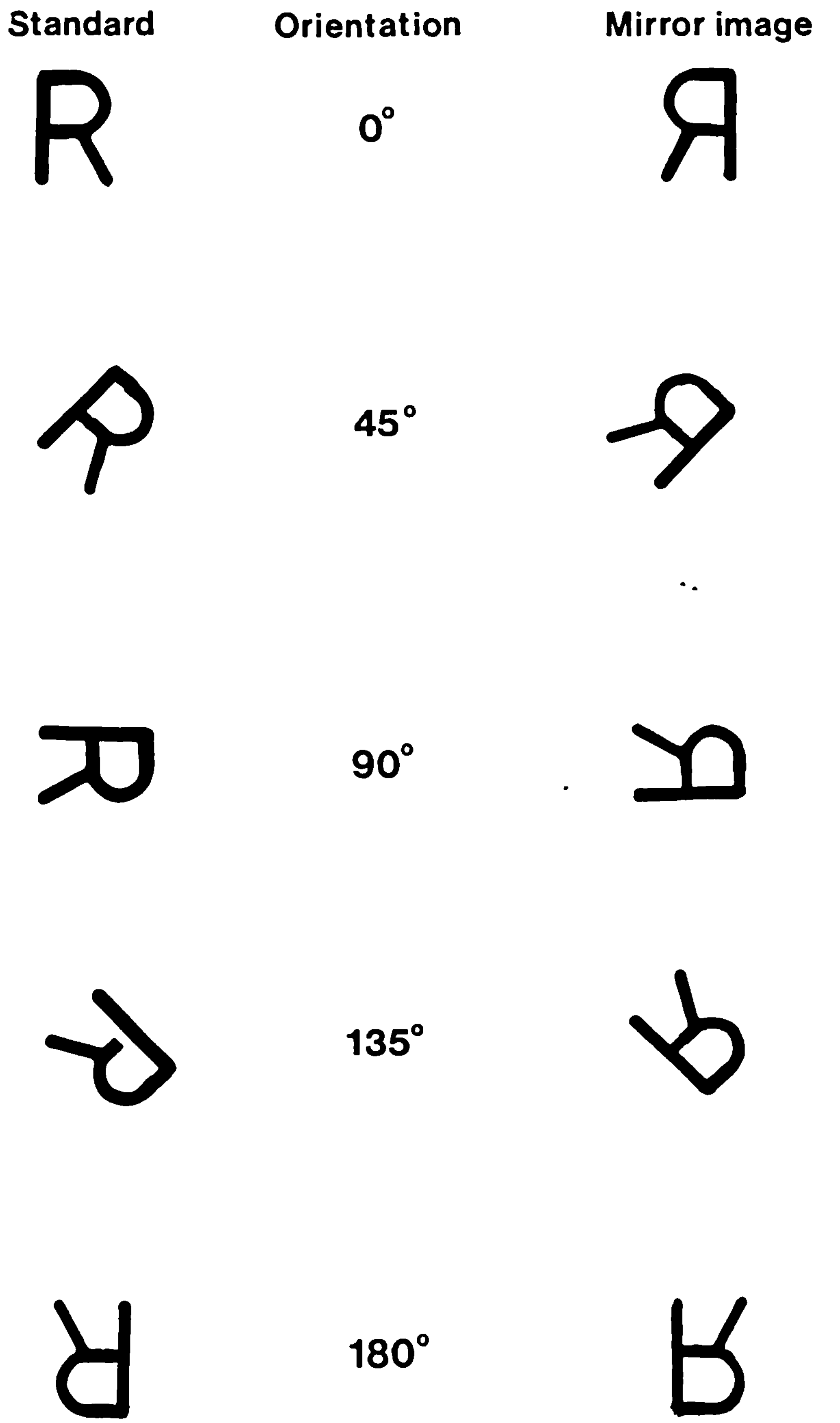
Two alphabetic characters were presented at each of the orientations and in both the normal and backward versions. Subjects were asked to decide whether the character on the screen was a normal or a reflected version and press the relevant key. If the subject pressed the correct key, the computer played a little tune and the following message was printed on the screen:

"WELL DONE. YOU ARE ABSOLUTELY RIGHT".

If the subject was wrong, there was no tune. The message printed was: "Sorry. Please try again". The experimenter (E) explained to the subject why he/she was wrong and let him/her have another go. This procedure was repeated until the E was confident that the subject had understood and was able to do the task. E also stressed that the subject should press the key as quickly as possible.

Figure 6.11

EXAMPLE OF AN ALPHABET CHARACTER AND ITS MIRROR IMAGE IN VARIOUS ORIENTATIONS



Stage 2. Test Phase

E pressed a key on the computer which started the programme. The whole procedure was automated from then on. A character (in any orientation and as a normal or backward version) appeared in the middle of the screen. The subject decided whether it was a normal or a reflected version of the letter and pressed one of two keys as soon as possible. This caused the character to dissapear from the screen. After 10 seconds, another character appeared. The test stimulus was programmed to stay on the screen for a maximum of two minutes. If the subject had still not pressed any key, the character disappeared and the next one appeared. This sequence continued until all 50 test items had been presented. The time between the onset of the test stimulus and the key being pressed was recorded automatically as the reaction time in milliseconds. For each trial, the subject's response was also recorded.

6.10 Results

6.10.1. Accuracy

The total number of responses correct for each orientation angle was obtained for each subject for the 'same' and 'different' pairs of stimuli separately. The percentages of correct responses for each group for each angle are shown in Tables 6.8 and 6.9.

The accuracy for all groups for both types of stimuli pairs is extremely high, ranging from 100% to 75%. However, only the Average IQ Autistic group was 100% accurate on all angles except 180 degrees on the 'same'

Table 6.8.
Percentage correct responses on 'same' trials (Alpha-numerics)

	Average IQ Autistic	Older Normal	Lower IQ Autistic	Younger Normal	Lower IQ Non-Autistic
N	8	17	7	14	12
Angle					
0deg	100	98	97	98	95
45deg	100	98	97	94	98
90deg	100	95	97	99	90
135deg	100	99	94	96	92
180deg	98	91	86	90	75

Table 6.9.
Percentage of correct responses on 'different' trials (Alpha-numerics)

	Average IQ Autistic	Older Normal	Lower IQ Autistic	Younger Normal	Lower IQ Non-Autistic
N	8	17	7	14	12
Angle					
0deg	95	98	94	93	87
45deg	95	99	91	94	90
90deg	95	94	94	94	87
135deg	98	94	94	93	82
180deg	100	91	91	87	78

pairs. Even on the 180 degree angle they maintained a very high level of accuracy. Their accuracy on this angle only dropped to 98% whereas it dropped to 91% for the Older Normal group. For the other three groups, too, the accuracy level was the lowest on the inverted (180 degree) letters. The Lower IQ Non-Autistic group, in particular, seemed to find these inverted letters most difficult. On the 'different' trials, all groups except the Average IQ Autistic group were least accurate on the inverted letters. The Average IQ group infact showed 100% accuracy on these inverted letters.

The high accuracy rates confirm again, as in the previous experiment, that the task was not too difficult for any group. The subjects in all the groups seemed to have understood the task requirements and did not seem to be responding randomly or by guessing.

6.10.2 Reaction Time Analysis

The reaction time data were analyzed using the same procedures as in the previous experiment. It will be recalled that the analysis is concerned only with the trials where the pairs of stimuli were the same. For each subject, the mean RT was obtained for all the correct 'same' trials for each angle of orientation. The group means and standard deviations are given in Tables 6.10 and 6.11. The individual subject data is given in Appendix (15).

6.10.2.1. Trend Analysis of the RT data

a. <u>Average IQ Autistic and Older Normal groups</u>

The mean RT as a function of the angle of orientation is plotted in Figure 6.12. This graph suggests that for both

TABLE 6.10.
Mean RT (1/100 sec) for Average IQ
Autistic and Older Normal groups: (Alpha-numerics)

	Average IQ Autistic (N=8)		Older Normal (N=17)	
	Mean	(SD)	Mean	(SD)
Angle				
0deg	144	(71)	116	(31)
45deg	187	(131)	129	(51)
90deg	166	(84)	172	(93)
135deg	181	(108)	172	(95)
180deg	217	(105)	213	(75)

TABLE 6.11.
Mean RT (1/100 sec) for Lower IQ Autistic,
Younger Normal and Lower IQ Non-Autistic groups (Alpha-numerics)

	Lower IQ Autistic (N=7)		Younger Normal (N=14)		Lower IQ Non-Autistic (N=12)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Angle						
0deg	170	(56)	137	(50)	134	(35)
45deg	187	(46)	202	(114)	187	(61)
90deg	189	(38)	204	(101)	209	(77)
135deg	227	(61)	234	(118)	268	(143)
180deg	318	(178)	251	(129)	329	(209)*

* The mean RT for this group for 180 degree is based on 10 subjects as 2 subjects did not respond correctly to any trials on this angle.

Figure 6.12

MEAN RT OVER ANGLE OF ORIENTATION: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS(ALPHA-NUMERICS)

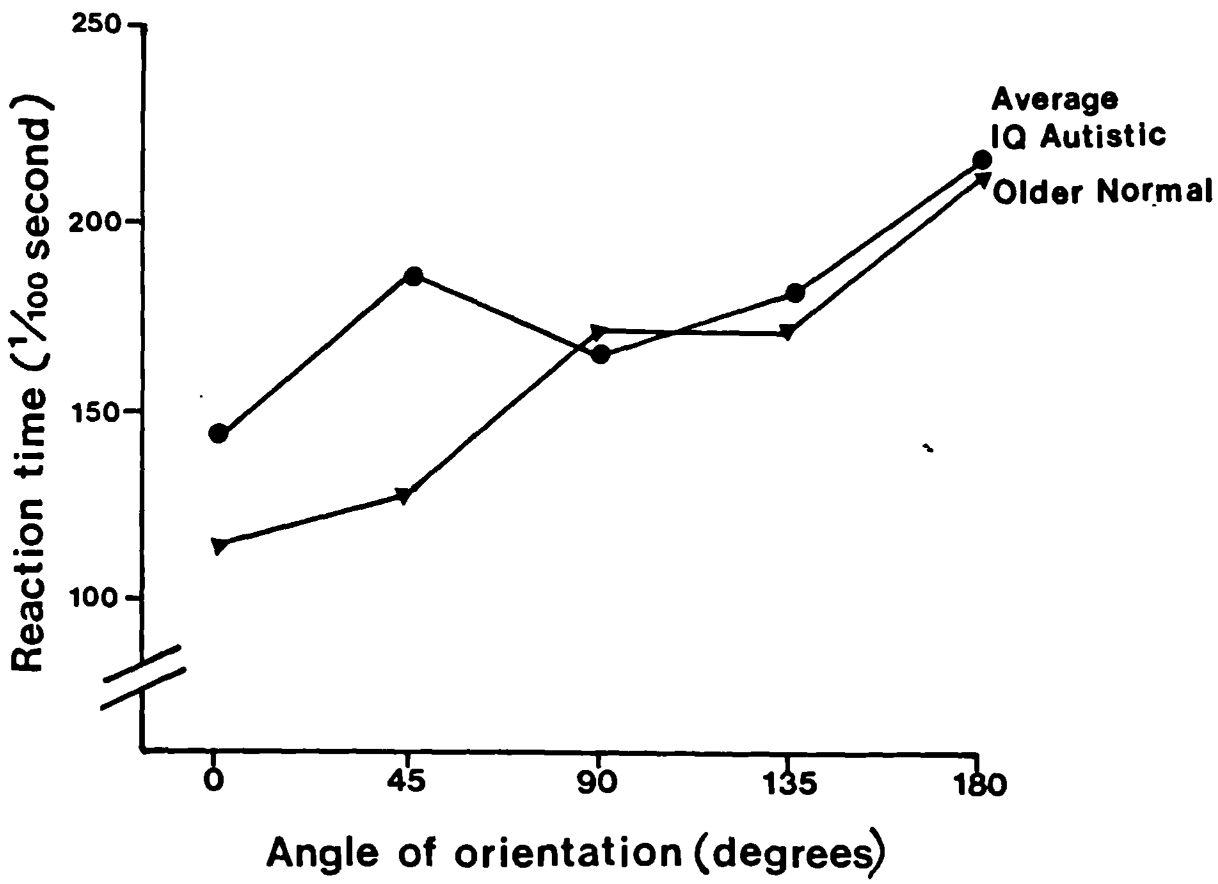
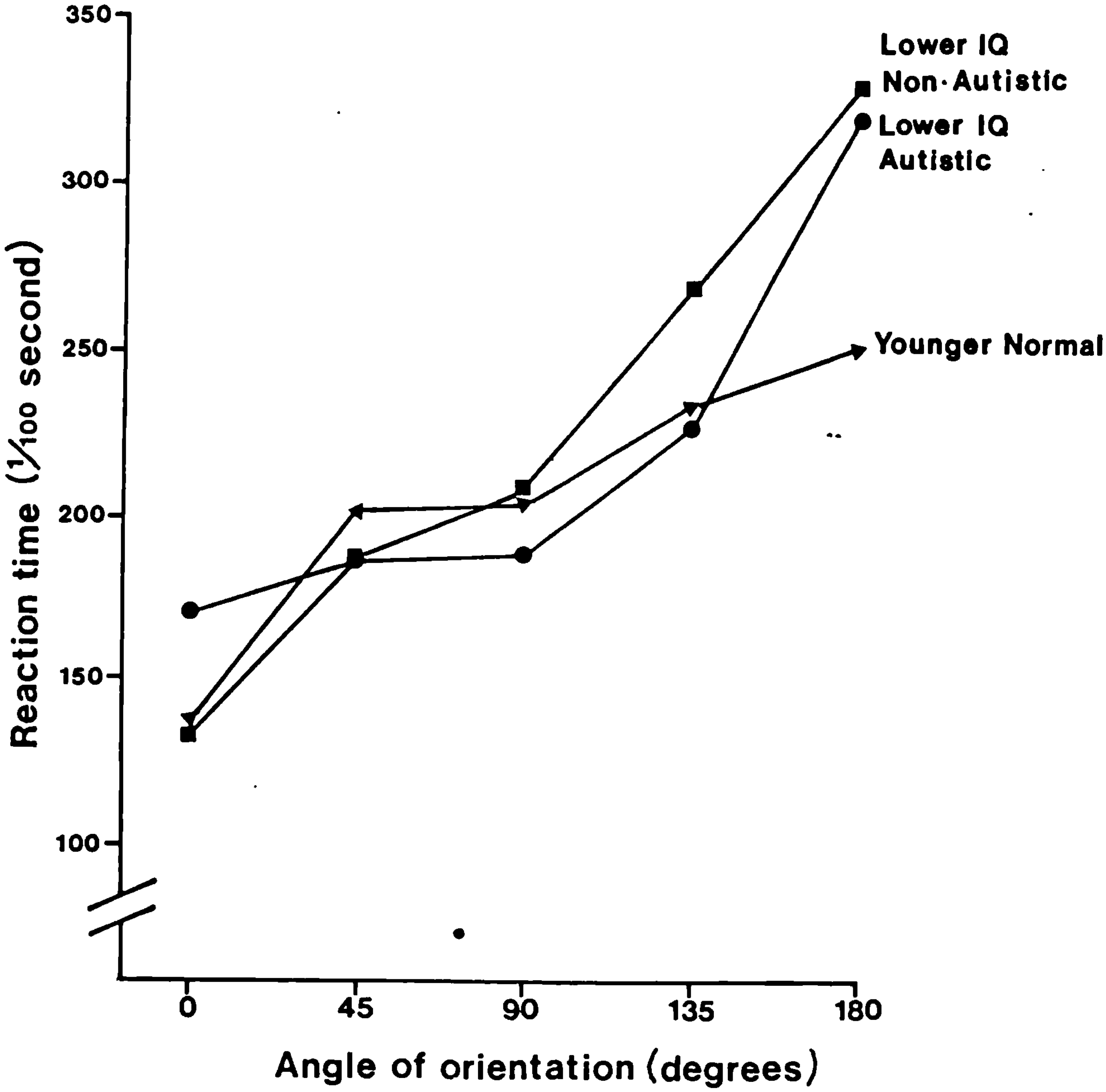


Figure 6.13

MEAN RT OVER ANGLE OF ORIENTATION: LOWER IQ AUTISTIC, YOUNGER NORMAL AND LOWER IQ NON-AUTISTIC (ALPHA-NUMERICS)



groups there is an overall linear increase in RT as the angle of orientation increases. The differences between the two groups and the statistical significance of this relationship was examined by a MANOVA for repeated measures and an orthogonal trend analysis (Hand and Taylor, 1987). There was a significant main effect of the angle of orientation ($F(4,20)=15.7265;p<.001$) indicating that RT on different angles of orientation were significantly different from each other. The interaction effect between group and angle was not significant which indicated that the differences in RT between the angles were not dependent on the group, i.e. for both groups, there was a significant effect of angle. The orthogonal trend analysis indicated a highly significant linear trend ($F(1,23)=41.634;p<.001$). This suggests that both groups are using a mental rotation strategy on this task, and justifies a detailed analysis of the linear functions which is reported below.

b. Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic groups

The mean RT as a function of the angle of orientation is plotted in Figure 6.13 for these three groups. For all three groups, there is a clear linear increase in RT with increasing orientation. For all three groups, the least increase in RT appears to be between the angles of 45 and 90 degrees. For the Lower IQ Autistic group and the Lower IQ Non-Autistic group, the highest increases in RT are over the larger angles of orientation. For the Younger Normal group, on the other hand, there is a much more gradual increase in RT even over the larger angles.

These differences and the significance of a linear relationship were further analyzed by means of a Repeated Measures MANOVA procedure and an orthogonal trend analysis. This showed that there was a significant main effect of angle ($F(4,25)=11.161; p<.001$) indicating that RT on different angles of orientation were significantly different from each other. This was true for all groups as the interaction effect between group and angle was not significant. The trend analysis for angle showed a highly significant linear effect ($F(1,28)=28.348; p<.001$). These results suggest that all three groups were using a strategy of mental rotation in this task. The differences between the groups regarding the rate of the mental rotation and other processes involved in the task are analyzed further below.

6.10.2.2. Further analysis of the RT data

As in the previous experiment, the linear function giving the slope and intercept estimates was obtained for each subject. The group means and standard deviations for these estimates together with the regression values are given in Tables 6.12 and 6.13.

The regression values which range from .61 to .71 indicate a strong relationship between RT and angle of orientation. These are not analyzed further. The slope and intercept estimates were compared statistically for the two sets of groups separately.

1. SLOPE

According to the model used here, the slope of the function relating RT to the angle of orientation provides an estimate of the rate of mental rotation.

TABLE 6.12
Mean Slopes, Intercepts and Regression: Average IQ Autistic and Older Normal groups (Alpha-numerics)

	Average IQ Autistic (N=8)		Older Normal (N=17)	
	mean	(sd)	mean	(sd)
Slope	.226	(.24)	.524	(.36)
Intercept	147	(90.2)	113	(41)
Regression	.61	(.34)	.72	(.17)

TABLE 6.13.
Mean Slopes, Intercepts and Regression: Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic groups (Alpha-numerics)

	(N=7) Lower IQ Autistic		(N=14) Younger Normal		(N=12) Lower IQ Non-Autistic	
	mean	(sd)	mean	(sd)	mean	(sd)
Slope	.757	(.69)	.592	(.54)	1.06	(1.06)
Intercept	146	(41.56)	154	(83.2)	132	(66.4)
Regression	.63	(.34)	.67	(.36)	71	(.38)

Figure 6.14

LINEAR FUNCTION RELATING RT AND ANGLE OF ORIENTATION: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS (ALPHA-NUMERICS)

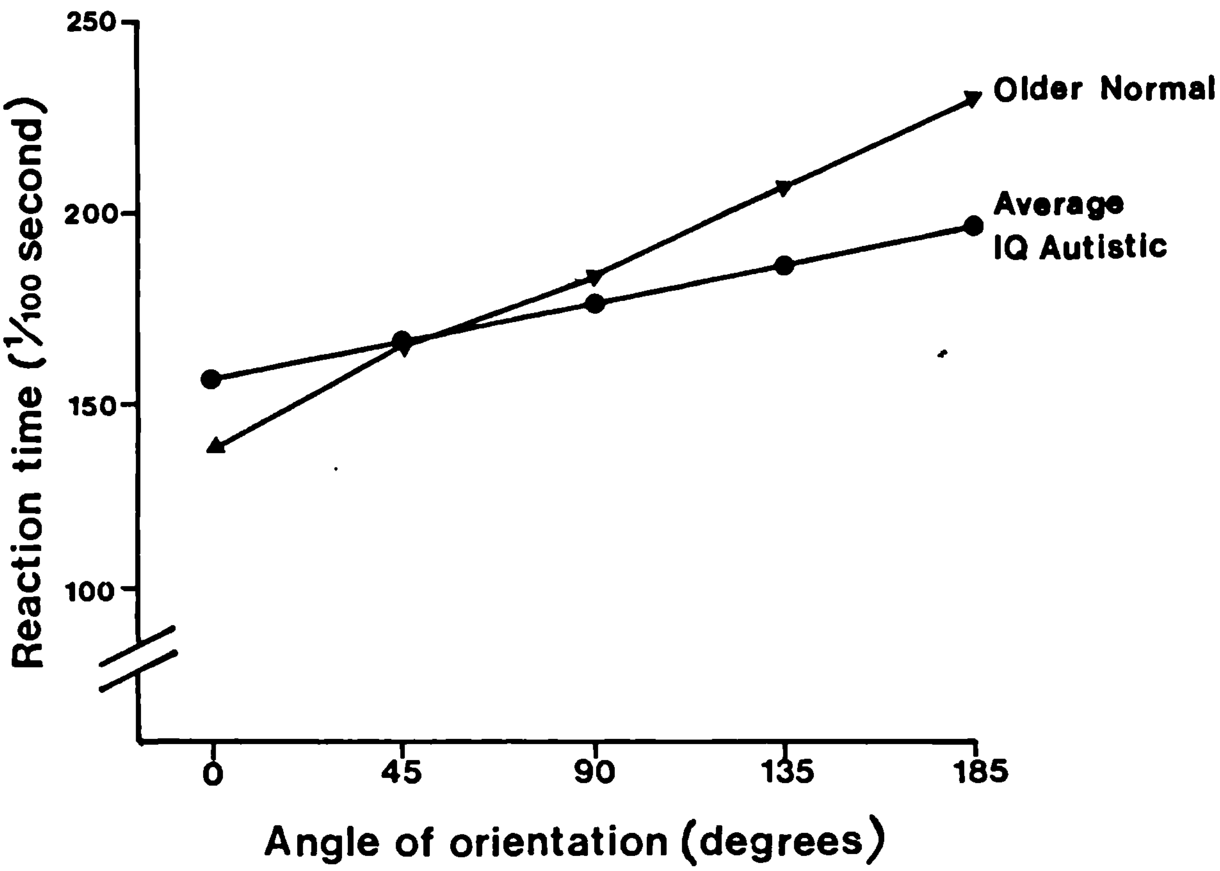
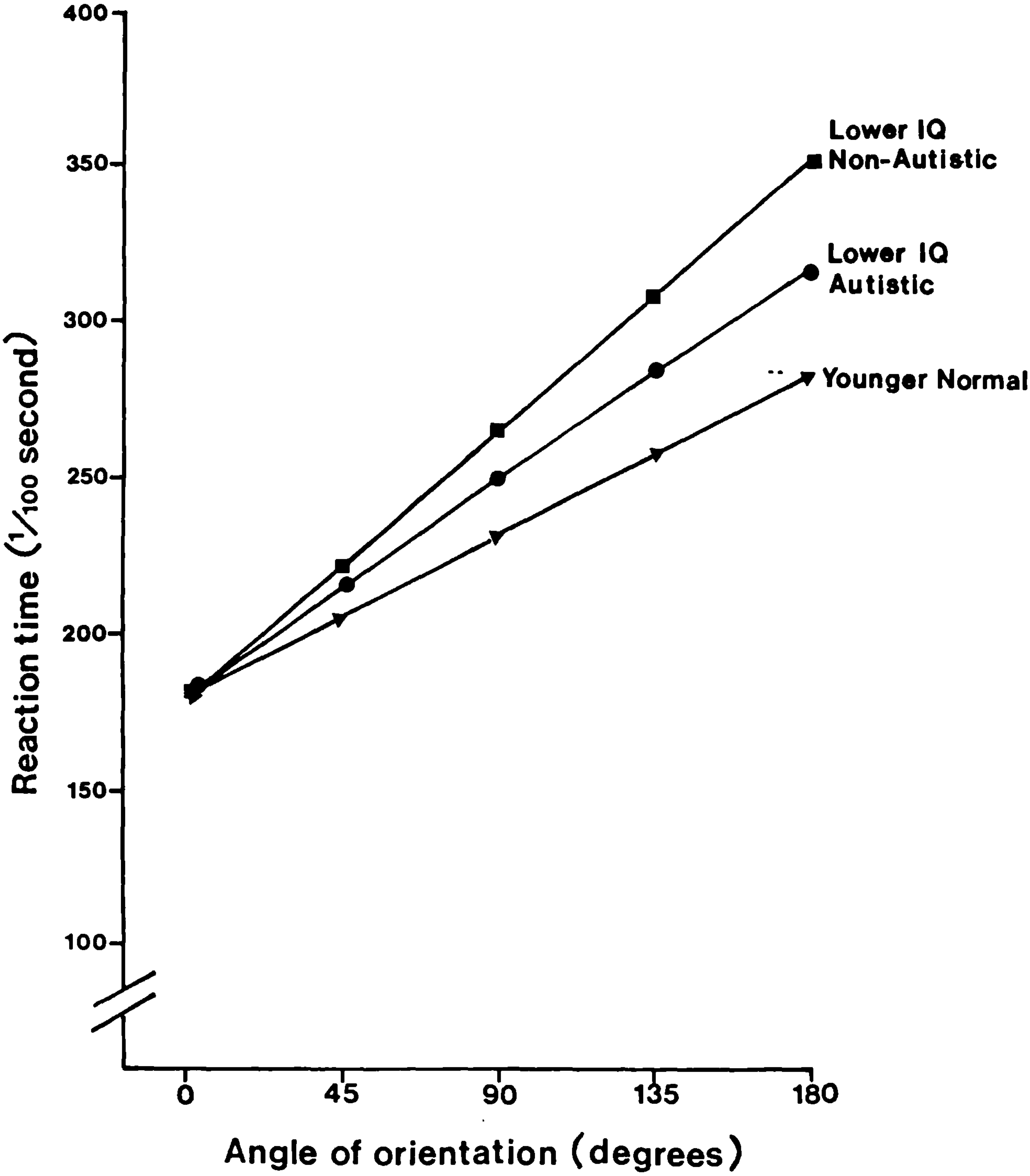


Figure 6.15

LINEAR FUNCTION RELATING RT AND ANGLE OF ORIENTATION: LOWER IQ AUTISTIC, YOUNGER NORMAL AND LOWER IQ NON-AUTISTIC GROUPS (ALPHA-NUMERICS)



a. Average IQ Autistic and Older Normal groups

The linear functions relating RT and angle of orientation are plotted in Figure 6.14. This graph shows clearly that the slope depicted by the line is much steeper for the Older Normal group than that of the Average IQ Autistic group. A between-group t-test on the slope values indicated that the difference between the groups was significant $(t=2.107;df=23;p<.05)$. This provides evidence that the Average IQ Autistic group was rotating the letters significantly faster than the Older Normal group. The estimates of actual speed were calculated from the slope values. These were .002 sec per degree or 450 deg per second compared to .005 sec per degree or 191 deg per second for the Older Normal group.

For each group, the speed of rotation and slope values for the alphanumeric stimuli are given in Table 6.14, together with estimates for the shape stimuli from the previous experiment. For both groups , the differences between the two types of stimuli were in the same direction. Alpha-numerics were encoded, compared and rotated faster than the shapes

b. Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic groups

The function relating RT to the angle of orientation is plotted in Figure 6.15. A one-way ANOVA indicated that there was a significant difference between the slopes of the three groups $F(2,30) =5.88;p<.01)$. Post-hoc tests showed which groups were significantly different from each other. The Lower IQ Non-Autistic group was significantly different from the Younger Normal group (post-hoc Tukey-HSD, SNK and

TABLE 6.14
Comparison of slope and rotation speed values for shape and alpha-numeric stimuli: Average IQ Autistic and Older Normal groups

	Average IQ Autistic (N=8) mean	Older Normal (N=17) mean
Slope		
Shapes	.833	.637
Alpha-numerics	.226	.524
Speed of Rotation (sec per deg)		
Shapes	.008	.006
Alpha-numerics	.003	.005
Speed of Rotation (deg per sec)		
Shapes	120	157
Alpha-numerics	353	191

TABLE 6.15
Comparison of slope and rotation speed values for shape and alpha-numeric stimuli: Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic groups

	Lower IQ Autistic (N=7)	Younger Normal (N=14)	Lower IQ Non-Autistic (N=12
Slope			
Shapes	1.164	.741	1.9
Alpha-numerics	.767	.577	.954
Speed of rotation (sec per deg)			
Shapes	.012	.007	.019
Alpha-numerics	.008	.006	.010
Speed of rotation (deg per sec)			
Shapes	86	135	53
Alpha-numerics	130	173	105

Sheffe tests, p<.05). The Lower IQ Autistic group was not significantly different from either group. The graph in Figure 6.15 shows this result very clearly. The Younger Normal group is the fastest and the Lower IQ Non-Autistic group is the slowest at rotating alpha-numeric stimuli. The difference between these two groups is big enough to be statistically significant. The Lower IQ Autistic group, on the other hand, is not as fast as the Younger Normal group or as slow as the Lower IQ Non-Autistic group. This group occupies a happy medium position which is not statistically different from either of the other two groups. This is further shown in the estimates of speed which are given in Table 6.15 together with the values for the shape stimuli for comparison purposes. This comparison indicates that all three groups encoded, compared and rotated alpha-numerics faster than shapes.

2. **Intercepts**

As explained in the previous experiment, intercepts provide a better estimate of the time taken to respond to the unrotated stimulus, i.e. at 0 degrees. According to the model adopted here, the intercepts reflect the time taken for the encoding and comparing processes of the task. These were compared for each set of groups.

a. <u>Average IQ Autistic and Older Normal groups</u>

Between-group t-tests indicated that there was no significant difference between the intercept values of these two groups. Thus, both groups took similar time for the encoding and comparing processes.

b. Lower IQ Autistic, Younger Normal and Lower IQ Non-Autistic groups

A one way ANOVA indicated that there were no significant differences between the intercept values of these three groups. This can be appreciated by referring to the graph in Figure 6.15 which depicts the linear functions. The estimated RT when the angle of orientation is zero is virtually identical for all the three groups. Thus, these three groups took very similar time for the encoding and comparing processes.

6.11 Discussion

This experiment was essentially a replication of the previous experiment but used familiar alpha-numeric characters instead of unfamiliar shapes as stimuli. The design was also slightly different as the standard alpha-numeric character did not need to be presented to the subject for each trial. The purpose was to investigate whether the visualization ability demonstrated by the autistic groups in the previous experiment extended to a task that required the test stimulus to be compared to a representation in long term memory.

The results regarding the accuracy levels confirmed once again that subjects in all groups had understood the task requirements and were not responding randomly. The hypothesis that the autistic groups would be less accurate than their respective control groups was not confirmed. In fact, the Average IQ Autistic group showed the highest levels of accuracy. They were 100% accurate on all the angles of orientaton except 180 degrees when the figures appeared inverted. This suggested that this group found this task extremely easy and yet showed the pattern of lower accuracy for the inverted figures. The accuracy of the Lower IQ Autistic group was similar to that of the Younger Normal group and the Lower IQ Non-Autistic group. Thus, this autistic group, too, did not seem to have any particular difficulty with this task. As expected, for all groups, the accuracy was the lowest for the 180 degree orientation.

The hypothesis that the two autistic groups would not show the usual linear relation between RT and angle of orientation was not confirmed. All the groups, including the two autistic groups showed a significant linear relation in the expected direction. This indicated clearly that RT increased proportionately as the angle of orientation increased. Thus, all the groups seemed to be using a method of mentally rotating the activated representation of the character in long term memory in congruence with the test stimulus in order to determine whether the two were the same or mirror-images. These findings regarding the high accuracy rates and the significant linear relationship between RT and angle for all groups provide strong evidence that both autistic groups were able to use a visualization strategy as efficiently as the control groups on a task that entailed manipulating a representation in long term memory and comparing it with an externally provided test stimulus.

These findings still appear discrepant from those reported by O'Connor & Hermelin (in Hermelin, 1978). As discussed earlier, these authors found that autistic children had difficulty on a visualization task that involved comparing a representation of a hand in long term memory with a model of a hand presented in various orientations to determine whether it was a left or a right hand. Unfortunately, these authors do not report how diffficult the task was for the autistic children. Although, by using familiar stimuli, the present task requirement was made very similar to their task, there were still differences in the presentation of the test stimuli and the type of subjects used. In particular, the autistic subjects in their study were blindfolded and could only feel the test stimulus. Thus, the representation of the test stimulus had to be derived by touch whereas, in the present study, the test stimulus could be encoded visually. The present results cannot be compared too closely with the study by O'Connor & Hermelin in view of the differences in design, in the precision of measures, and in the type of autistic subjects used with regard to overall non-verbal intellectual ability. On the basis of the findings of the present study which used very homogeneous subgroups of autistic subjects and precise reaction time measures, it has to be concluded that autistic subjects with performance IQ above 60 do not have any difficulty with a visualization task that entails manipulating a representation in long term memory and comparing this representation with a visually encoded test stimulus.

The hypothesis that the two groups of subjects would be slower on all the component processes of this task than their respective control groups was not confirmed. These findings will be discussed separately for each autistic group.

The Average IQ Autistic group was compared with the Older Normal group. As showed by the intercepts of the linear functions relating RT to angle, there was no difference between these two groups in the rate at which they encoded and compared the stimuli. However, there was an interesting and a surprising difference in their rates of mental rotation. The Average IQ Autistic group was significantly faster at rotating the representations of alpha-numeric characters in long term memory than the Older Normal group. The rate of rotation of the Average IQ Autistic group (450 degrees per second) was even faster than the rates reported for normal college students in a study by Kail et al (1980). These findings, together with their 100% accuracy on most angles provide evidence that this group of autistic subjects found this task extremely easy and was able to reach super-normal levels on the mental rotation component of the task. Both the Average IQ Autistic group and the Older Normal groups were able to encode, rotate and compare alpha-numeric characters much faster than the unfamiliar shapes presented in the previous experiment. However, the difference between the two types of stimuli was exceptionally large for the Average IQ Autistic group. Thus, they perform at normal levels when visualization involves manipulating a recently encoded shape, but reach super-normal levels when visualization involves manipulating a representation in long term memory.

The Lower IQ Autistic group was compared with the Younger Normal group and the Lower IQ Non-Autistic group. There was no difference between these three groups on the encoding and comparing components of the task. All three groups were faster on these processes on these alpha-numeric characters than they were on the unfamiliar shapes. There were interesting differences between the groups regarding the speed of mental rotation. The Younger Normal group was the fastest on this. The Lower IQ Autistic group was slower than the Younger Normal group, but this difference was not large enough to be significant. The Lower IQ Non-Autistic group, on the other hand, was significantly slower than the Younger normal group. The Lower IQ Autistic group was not as slow as the Lower IQ Non-Autistic group, but the difference between these two groups did not reach statistical significance either. It was interesting to compare the rates of speed of these groups with those reported by Kail et al (1980). The speed of the Younger Normal group (173 degrees per second) was similar to that reported by Kail et al for their normal 8-9 year old subjects. However, as would be expected from the pattern of differences between the groups, the Lower IQ Autistic group did not quite reach this level.

It is interesting that all the groups were able to encode, rotate and compare alpha-numeric characters faster than the unfamiliar shapes used in the previous experiment. This is a well established finding which has been frequently reported (Cooper & Shepard, 1973; Kail et al, 1980). This suggests differences in processing the two types of stimuli. The essential difference between the two types of stimuli is that alpha-numeric characters are learned and stored in long term memory whereas the unfamiliar shapes have no such internal representation. Encoding is faster for the alpha-numeric, presumably because encoding in this case involves activation of an internal readily available and labelable pattern. The shape stimulus, by contrast, has to be encoded from scratch. The comparing process for the alpha-numerics must be faster as it involves comparing the test stimulus with the internal representation. Similarly, the mental rotation is faster as it is the internal representation which is rotated.

6.12. Conclusions from the two experiments on visualization

It can be confidently concluded, on the basis of the two experiments investigating visualization ability on two-dimensional visuo-spatial tasks, that both autistic groups are able to use a strategy of visualization in tasks with familiar or unfamiliar stimuli.

The performance of the Average IQ Autistic group is qualitatively and quantitatively similar to that of the Older Normal group on all the components of the visualization task using unfamiliar shapes as stimuli. They use the same strategies and perform all the required mental operations at the same rate as this stringently matched normal control group.

The performance of the Average IQ Autistic group is qualitatively similar to the Older Normal group on the task using familiar alpha-numeric characters as stimuli, but there are important quantitative differences on certain mental processes involved in the task. Both groups perform at the same rate on the more basic processes of encoding and comparing stimuli, but the the performance of the Average IQ Autistic group significantly excels that of the Older Normal group on the more complex process of mental rotation. The Average IQ Autistic group is able to rotate mental representations of alpha-numeric characters at a super-normal level.

The performance of the Lower IQ Autistic group is qualitatively similar to that of the Younger Normal group and the Lower IQ Autistic group. However, the Lower IQ Autistic group is significantly slower on the encoding and comparing components of this task than the Younger Normal group as is the Lower IQ Non-Autistic group. The findings regarding the speed of mental rotation are less clear cut. The Lower IQ Autistic group rotated stimuli faster than the Lower IQ Non-Autistic group and slower than the Younger Normal group but the difference in either case is not big enough to be statistically significant.

On the visualization task using familiar alpha-numeric characters as stimuli, the performance of the Lower IQ Autistic group is qualitatively and quantitatively similar on the encoding and comparing processes to that of both the control groups. There are no differences between these three groups in this respect. However, the picture regarding the rates of mental rotation remains the same as for unfamiliar stimuli. Again, the Lower IQ Autistic group is not as fast as the Younger Normal group or as slow as the Lower IQ Non-Autistic group.

The findings of these experiments on visualization skills of the two autistic groups suggest that an important contributory factor towards their islet of ability on visuo-spatial tasks is an intact visualization ability. The level of efficiency that each group reaches on the mental rotation component of these tasks is in keeping with their ability levels on the block design task. Visualization is an important component of many visuo-spatial tasks , including the block design. Having established that this is one underlying skill that contributes to the autistic person's excellent performance on visuo-spatial tasks, the next step is to identify other such underlying cognitive abilities. The next experiment (No. 4) tackles this by using the paradigm of the block design task itself.

6.13. Summary of Chapter (6)

In this chapter, two experiments investigated visualization ability in autistic people.

The first experiment used unfamiliar shapes as stimuli and subjects were required to decide whether two given shapes in any of 5 orientations were identical or mirror-images. The results showed that both groups of autistic subjects used a visualization strategy of mental rotation previously described for normal adults. The Average IQ Autistic group performed similarly to the Older Normal group on all component cognitive processes of the task. The Lower IQ Autistic group, however, was slower on encoding and comparing components of the task than the Younger Normal group.

The second experiment used familiar and nameable stimuli, i.e. alpha-numerics. The subject was required to compare an alpha-numeric symbol, presented in any of 5 orientations with a mental representation of the symbol in long term memory (LTM). Again, the results showed that all the groups, including the two autistic groups, used a visualization strategy of mentally rotating a representation in LTM. An interesting quantitative difference between the Average IQ Autistic group and the Older Normal group was that the autistic group rotated alpha-numeric symbols significantly faster.

It was concluded that a normal and super-normal visualization ability is one aspect which contributes to the respective performance levels of the two autistic groups on their visuo-spatial islets of ability.

CHAPTER SEVEN

Experiment 4 - Cognitive components of the block design task

7.1. Introduction

The preceding two experiments concerning mental rotation ability identified one aspect of visuo-spatial skill, namely visualization ability which goes some way in explaining the high scores of the autistic subjects on tasks such as the block design. This experiment aims to elucidate other underlying cognitive skills and stategies which may contribute to their superior performance on such tasks. In this experiment, the paradigm of the block design task itself is used. The component sub-skills of the task are analyzed and incorporated into modified versions of the task such that the effects of each of these can be investigated separately. First, the literature related to the block design task is reviewed.

7.1.1. The Block Design Task - Literature Review

The block-design task was invented in 1923 by Kohs (1923), a clinical psychologist. It was among a large number of mental tests invented during the 1920's when applied psychology first came into prominence. Kohs(1923) considered his test to be an adequate measure of intelligence in itself. The following quotes express his justifications of this view:-

> "It requires first the breaking up of each design presented into logical units, and second a reasoned manipulation of blocks to reconstruct the original design from these separate parts. The results of the activity, it is presumed, yield a fair index of this analytic-synthetic power which we have termed 'intelligence'.

.... If intelligence involves the following mental operations:- analyzing, combining, comparing, deliberating, completing, discriminating, judging, criticizing and deciding, the block design tests may be said to call upon the functioning of intelligence and to that extent they are measures of mental capacity". (Kohs, 1923).

Kohs also reported that the test assisted in differentiating the feeble-minded from the borderline or normal group, and correlated highly with the Binet test. He thus suggested that the block test may be usefully substituted for the Binet, especially as it required little language understanding.

In the 1930's, The Kohs Block Design Test was used either as a measure of intelligence by itself or in collections of tests assessing mental ability (e.g. Arthur Point Scale of performance; Alexander Performance Scale (Alexander, 1932)). It was considered a good non-verbal measure of analytic and synthetic reasoning with a wide range of difficulty, and discriminative capacity. Since 1923, there have been numerous revisions and restandardizations. Each modification alters the number of items or the directions, or the scoring procedures, or introduces new designs but the basic task of constructing designs from blocks has remained as Kohs introduced it.

In the past, there has been a lot of interest in the clinical use of the block design test. Various authors (Bolles & Goldstein,1938; Nadel,1938) have reported that patients suffering from cerebral lesions and schizophrenia did poorly on the test. Such observations have been the basis of many theoretical and practical conclusions. In particular, the poor performance on the test has been considered as evidence of a fundamental defect in the patient's intellectual capacity. Various terms such as 'loss of synthetic ability', or 'loss of abstract thinking' or 'inability to serialize' have been used to describe the behaviour resulting from a change due to an organic lesion interrupting areas subserving higher mental functions. The studies in this context have been directed either at establishing the use of the block design test for diagnosing brain damage, or at a more qualitative analysis to pinpoint the difficulties on the task for the brain damaged patients.

As with other tests, attempts were made to find criterion performance on the test that differentiated between clear-cut brain-damaged patients and normal subjects. For example, Shapiro (1951; 1952; 1954) found that, on the block design task, some subjects, while reproducing the design correctly, left the blocks in an obviously rotated position. Shapiro (1952) reported that the rotation effect occured much more frequently among brain-damaged psychiatric patients than among non brain-damaged psychiatric patients. He used a cut-off point of 6% rotation to identify 14 out of 19 brain-damaged subjects and misclassified one functional patient. Shapiro (1952) suggested that the effect of the rotation may be associated with lesions occuring in any part of the brain, and in particular to the inhibition of sensory cues produced by the brain-damage. However, his studies (Shapiro 1952; 1954) suggested that an increase in central nervous system inhibitory process in brain-damaged subjects was not necessary to account for the rotation, but that the visual field and occulomotor defects were more important.

The Goldstein-Scheerer Test Battery (Goldstein and

Scheerer, 1941), developed as a measure of deterioration in organic brain damage, also includes a modified version of the block design test. Goldstein and Scheerer (1941) argued that brain-damaged patients are not able to succeed at this task because they are unable to use the abstract reasoning approach required in the test. The battery, as an assessment tool for brain-damage, has been heavily criticized (reviewed in Payne,1965). Its main drawbacks are inadequate norms, no evidence on reliability, and its reliance on the concept of abstract reasoning which is assumed to be peculiar or absent in brain-damaged patients. Other studies (Tooth,1947; Mcfie & Piercy,1952) have failed to distinguish brain-damaged patients from other groups on this measure. However, it is important to note that Goldstein & Scheerer, in their attempts to justify inclusion of the test in the battery, did provide detailed analysis of the various requirements for successfully completing the block design task. They emphasized that the brain-injured person uses a concrete approach and does not attempt to detach himself from the contents of his immediate apprehension. He does not match the block-sides to separate parts of the design, but rather tries to form a global pattern. This is done by manipulating and turning up their sides until he sees that they match the figure of the model. The authors list the steps necessary for abstract and thus successful performance. These are as follows:-

1. the given size of the design and the coherent total impression of the design has to be disregarded;
2. an imaginal network of equal squares has to be imposed upon the design;

3. these imaginary square units have to be held in the mind and matched with appropriate block sides;
4. the identified block sides have to be organized into a construction.

The author's summary of the procedure is rather amusing:

> (To succeed at the task one needs .....)
> "to detach one's ego from the immediate and primal impression of the model as one unreflectively apprehends it; to wilfully assume the mental set as described above as formalized and conceptualized procedure, and to account for it consciously."
> (Goldstein and Sheerer, 1941, p.34).

Other authors have also tried to identify procedures which would lead to successful performance in brain damaged people, with a view to developing and using block design materials and methods as an aid for evaluating and training people who had deficits in visual perception, visuo-motor performance and visual organization as a result of brain injury.

Reissenweber (1953), on the basis of clinical observations of performance on the task has made practical suggestions about ways in which Kohs block test can be simplified, that is by:

1. using drawings with black lines that indicate the divisions between blocks;
2. by numbering the bricks to emphasize the division into four parts;
3. by enlarging the drawing so that the drawing corresponded exactly to the size of the 4 bricks;
4. by deepening the outlines of the designs and painting with a coat of glossy nail polish.

Reissenweber found that the task still proved difficult for a lot of the patients. She thus further manipulated the task by using a specially devised inclined surface on which both the design card and the block design appeared as 3-dimensional. This was to overcome the dissimilarity between the flatness of the design card and the completed 3-dimensional block design. She also rearranged the physical environment in order to reduce the effects of the contours and surfaces of objects within the visual range.

Nadel (1938) also did a qualitative analysis of the performance of brain-damaged and normal subjects on the block design task. Nadel presented the subjects with a design from Kohs test. If the subject was unable to construct the design correctly, more and more simplified versions were provided. The task was simplified by:-

1. making the design the same size as the space occupied by the completed model;
2. using designs with lines drawn to delineate the outlines of the blocks;
3. by presenting a model instead of a card design which the subject had to replicate;
4. by presenting the subject with four designs, made of blocks, one of which was correct. The subject had to select the correct design from the group.

The results of this study showed that the experimental group could only solve the unsimplified task 52% of the time compared to the control group successes of 93%. The control group were able to succeed more often on the simplified versions of the task. Analysis of the errors suggested that the most common difficulty for the experimental group seemed to be their inability to break the design into its component block elements. Instead, they seemed to follow the 'figures' created by the designs, thus building the 'figures' of the design.

In contrast to these studies which point at the difficulties posed by the block design task for certain subjects, one study (Eigler,1930) reported that some pre-school children had remarkably high scores on the test. For example, he reported that one child who was 3.1 years old had a Kohs block design score of 12.1 years. Another 4.7 year old child had a score of 12.7 years. To check on this unusual findings, Benton (1938) studied the block design performance of 30 pre-school children of comparable IQ level to Eigler's group. He did not find the occurence of extremely high scores. He concluded, therefore, that at least the frequency of such high scores is not as great as Eigler's report would suggest. Since then, there has not been any attention paid to Eigler's unusual findings. In the light of knowledge about how well some autistic subjects perform on the block design task, one wonders whether there were indeed some autistic children among Eigler's subjects. Unfortunately, no clinical data is available on these subjects who performed so remarkably.

In recent years, as ideas have changed regarding the measurement of intelligence, the block design test is not used as a tool by itself for measuring intellectual ability but it constitutes an important part of the popular batteries for measuring intelligence. For example, it features in the Wechsler Intelligence Scale for Children (Wechsler, 1974), and for adults (Wechsler,1955), and The British Ability Scales (Elliot, Murray and Pearson, 1979). In these tests, the block design task is considered a useful tool for measuring non-verbal abstract conceptualization and spatial visualization (Sattler, 1974). Factor-analytic studies of the Wechsler Scales show that the block design subtest contributes substantially to the space-performance or perceptual organization factor (Maxwell, 1959; Cohen, 1959). It is also found to be the best measure of g among the performance scale subtests and is the fourth-best measure of g among the twelve subtests. This corroborates Kohs' (1923) earlier contentions about the value of the test as a non-verbal measure of general intelligence. In recent years, there have not been any studies which have analyzed the performance of special groups of people on the block design task in terms of the strategies used.

To summarize, it is clear from the above review of the literature that the block design task has held a significant place in psychological testing of intelligence since the time it was introduced by Kohs. Another point that emerges is that this task poses particular difficulty for people with organic brain-damage. The task appears to require a constellation of subskills, many of which are susceptible to effects of brain damage. The following section considers the nature of the component subskills in more detail.

7.1.2. Component subskills of the block design task

The steps involved in constructing the block design can be specified as follows:-

1. The given size of the design on the card has to be disregarded by deducing that the design is to be made

by arranging the four blocks together to form a square, the area of which is much larger than the area depicted in the design on the card;

2. The design has to be mentally segmented into four equal squares; This involves overcoming the tendency to see the design as a whole;

3. The subject has to mentally hold the imaginary square units and select the correct side of each brick to match each square;

4. The brick has to be positioned correctly. This involves turning the block as necessary so that the orientation and position of any line separating the two colours is the same as that on the card. The orientation aspect is more relevant when the line separating the two colours is an oblique rather than vertical or horizontal.

The specific cognitive skill required for steps 1 and 3 is that of visualization. This skill was investigated in detail in the last two experiments. In this experiment, the specific cognitive skills required for steps 2 and 4 are investigated. The skills subsumed under step 2 can be referred to as 'segmentation of the whole', and the cognitive component on which performance of step 4 is dependent on will be referred to as 'perception and reproduction of the oblique'. The literature regarding each of these component skills is reviewed.

7.1.2.1. Segmentation of the whole

Gestalt psychologists (e.g. Wertheimer, 1923; Koffka,

1935) have ascribed great importance to the tendency to perceive patterns as wholes rather than as collections of details. These psychologists emphasize that a whole is not merely the sum of its parts but that there are characteristics of the whole which are different from those of the parts. In normal perception, there is a strong tendency to perceive patterns as wholes. This is effortless. However, when details of the whole need to be perceived, the forcefully created gestalt in the immediate perception has to be broken down and new gestalten have to be imposed in accordance with the perceptual set of the organism. Gestalt theory has identified laws of perceptual organization which contribute to this tendency to perceive the whole rather than the parts. These include factors such as proximity, similarity and continuity. The law of continuity is of particular relevance to the segmentation skill required in the block design task. In gestalt terms, the pattern given on the card is perceived as a whole because the lines of contour separating the two colours on each block continue on the adjacent blocks. Segmentation , then , requires extra effort because of the strong tendency in normal perception to follow a continuous linear contour.

The research regarding the development of the ability to overcome the tendency to see the whole has used two-dimensional tasks which involve the breaking up of a given 'whole' figure to succeed at the task. For example, Walters (1942) found that visual illusions such as the 'Müller-Lyer' have a greater effect on children than on adults. Many of these 'visual illusions' have their effect because the observer's perception is influenced by the inclusion of their parts in the whole pattern. Ghent (1956) found that it was particularly difficult for children to perceive figures that were not clearly set apart from each other, especially when they shared a contour as in the case of embedded figures. Witkin (1950) compared the ability of adults and 10 year old children to locate a simple figure embedded in a complex one. Children had much greater difficulty than adults and took much longer. Other techniques which have provided evidence for the difficulty experienced by young children in perceiving small details in complex wholes include descriptions of complex pictures (Cramaussel, 1924) , perception of differences between a pair of pictures which differed in small detail (Segers, 1926) and the descriptions on the Rorschach test (Ames et al., 1953; Meili-Dworetzki, 1956; Hemmendinger, 1953). The results of these studies show that by middle childhood, the ability to break up the gestalt, if required, is developed. However, children are less efficient at this than adults.

The ability of segmenting the whole seems very susceptible to the effects of brain injury. Defective performance on hidden figures tests after brain injury has been demonstrated repeatedly in adult patients (e.g Teuber et al, 1951; Teuber and Weinstein, 1956), and in brain-damaged children (Cobrinik, 1959). The studies on the block design performance of brain-damaged patients reviewed earlier (Bolles & Goldstein, 1938; Nadel,1938; Reissenweber, 1953) also showed that the segmentation of the design into its component blocks was the most difficult aspect for such patients. These studies are all of an era when the concept of brain damage referred to global damage. Thus, there is no information on the nature of the impairment, its relation to other sequelae of cerebral injury or its possible dependance on particular regions of the brain. Studies regarding hemispheric effects on segmentation ability have proved inconclusive. For example, Teuber and Weinstein (1956) and Pizzamiglio and Carli (1974) found no significant differences between patients with right and left unilateral brain damage on visual embedded figures tasks. However, other studies (e.g. De Renzi and Spinnler, 1966) have implicated the right hemisphere as being involved in segmentation ability. The confusion seems to be partly due to the hetereogeneity of the type of embedded figures used and often due to the difficulty of controlling for the severity of lesions in the right and left hemisphere groups.

7.1.2.1.1. Segmentation ability in autism

The study by Shah and Frith (1983) investigating the performance of autistic children on the Children's Embedded Figures Test (CEFT) provides the most direct evidence regarding their ability to break up the gestalt and to perceive the parts independently of the whole. The finding of the study that they were significantly more accurate at locating the embedded figure than the control groups indicates that the ability to overcome the tendency to perceive the whole and to break it up into its constituent elements is intact in autistic children. The evidence provided in the last experiment regarding their ability to visualize suggests that it was segmentation ability per se which contributed to their high scores on the CEFT rather than this factor combined with lack of ability to visualize.

However, this study used only one group of autistic subjects. The range of intellectual ability of the group was not as homogenous as in the present study. Thus, it is not clear whether autistic subjects of all levels of non-verbal IQ show a superior ability to segment the whole. In view of the differences in the block design scores of the Average IQ Autistic group and the Lower IQ Autistic group in the present study, it is possible that there may be differences between the groups regarding segmentation ability.

7.1.2.2. Perception and reproduction of the oblique

The first account regarding the difficulty of perceiving the oblique orientation was published in 1893 by Jastrow who reported that subjects required to reproduce visually presented lines or to set lines to particular orientations were less accurate when the lines were oblique than when they were vertical or horizontal. There is now a whole body of literature which suggests that the oblique presents particular difficulty at all levels, that is in perception, discrimination and reproduction. A selection of this research is briefly reviewed.

Various studies of perception of a line target have shown that oblique lines are perceived slower and less accurately than horizontal and vertical lines (Burns, Mandel, Pritchard & Webb, 1969; Liebowitz, Myers & Grant, 1955). Ogilvie & Taylor (1958) reported that for a fine wire to be visible in an oblique orientation, it must be twice as wide as in a vertical or horizontal orientation. Olson & Hidyard (1977) found that 14 year old children found it signifcantly easier to search for arrows bearing a horizontal or vertical orientation than for those bearing an oblique orientation.

Studies on discrimination ability have shown that children as young as 6 years are able to discriminate an oblique line from a vertical or a horizontal line as readiliy as they can distinguish vertical and horizontal lines (Rudel & Teuber, 1963). Difficulty arises when the child is required to discriminate one of two opposite diagonals. They choose the opposite oblique almost as often as the original. Bryant (1969) compared the performance on discrimination of obliques with other 'mirror-image' stimuli and concluded that although obliques are recognized as different from vertical or horizontal, the difference in direction of their slope is not encoded in memory, and the difference is more difficult to recognize than it is for other mirrored images. Olson & Hidyard (1977) found even normal adults took longer to make same-different judgements about oblique lines than about vertical or horizontal lines.

The difficulty of the oblique extends to drawing and construction. According to the norms developed on the Stanford-Binet Intelligence Scale (Terman and Merrill, 1960), the ability to copy a diamond shape is expected at a later age than a square. Olson (1970) has reported that children in both 'carpentered' and 'uncarpentered' environments find it very difficult to construct the diagonal across a chequerboard.

There is evidence that the perception of the oblique is particularly susceptible to the effects of brain damage. Rudel & Teuber (1971) have reported that children and adults with brain damage tend to select a square more frequently when asked to cross out a diamond shape where it occurs on a page full of shapes. The studies by Shapiro (1951; 1952; 1954) reported earlier showing the tendency of brain-damaged patients to leave the blocks in a rotated position suggests difficulties with the oblique orientation. It is interesting to note that none of the studies of qualitative analysis of the performance of the block design task have considered the effect of the oblique. This omission is probably related to the fact that the majority of the evidence concerning the difficulty posed by the oblique has appeared much later than the studies on the block design test.

Although the paradox of the oblique is a well established phenomenon, there is no satisfactory explanation. Various explanations have been proposed. It has been suggested that the complexity of the language required to describe the obliques makes them more difficult to remember and discriminate. The terms 'vertical' and 'horizontal' are used to distinguish up-down from left-right axes, which are 90 degrees apart, but there is no distinguishing term for opposite obliques, also 90 degrees apart. They can be described only by combining the vertical-horizontal vocabulary. A related problem may be that the horizontal or vertical occupy only the left-right, or the up-down co-ordinates of space. But the obliques occupy both these co-ordinates of space simultaneously, being 'up to the right' or 'down to the left'.

It has been suggested that the difficulty of the oblique is related to the fact that there is very little in the external context to compare it with. There is evidence that the immediate external context affects the ability to discriminate obliques. Huttenlocher (1967) reported that children were able to discriminate between the two obliques more accurately when they were placed one above the other instead of side by side. Bryant (1974), also found that when an appropriate external cue (a thick red oblique line) was provided against which each pair of obliques could be compared, children found it easier to make successive comparisons between the obliques more easily. It seems unlikely , though, that the wider external context has much effect on the ability to perceive and discriminate the oblique, especially in view of the evidence (Olson, 1970) that children in 'uncarpentered' environments find it as difficult to construct diagonals as children in 'carpentered' environments. More research is needed to ascertain why the oblique has such a powerful effect.

7.1.2.2.1. The effect of the oblique in autism

To date, there are no studies which have investigated the effects of the oblique in autistic subjects. The present study which investigates the effects of the oblique on the block design performance of two groups of autistic subjects can be considered a fact finding study.

7.2. Aims and Hypotheses

The aim of the present study is to investigate the cognitive strategies used by autistic subjects and control subjects on the block design task. In particular, the study investigates which component of the block design task contributes to the super-normal performance on the task by the Average IQ Autistic group and the normal performance by the Lower IQ Autistic group. The study investigates the effects of three component factors , and the interaction effects of these factors on the time taken to construct the designs. The three factors are as follows:

1. the wholeness of the design;
2. oblique contours within the design;
3. rotation of the design.

High performance levels on visuo-spatial tasks may be due to facility in processing information related to all three factors. Because of the lack of relevant studies, it is not possible to make any firm predictions regarding the effects of the oblique contours and rotation of the design on the performance of the autistic groups.

However, the wholeness of the designs may affect the performance of autistic groups differently. In particular, it is predicted that physical segmentation of the design will not affect the performance of the autistic groups to the same extent as their respective control groups. This is based on the evidence from their performance on the Children's Embedded Figures Test (Shah & Frith, 1983). This evidence suggests that they will be able to overcome the tendency to see just the 'gestalt' and will be able to mentally break up the given 'gestalt' easily. Thus, they may not need the help given by the physical segmentation to the same extent as control groups.

If autistic subjects show superior ability relating to spatial factors of the Oblique and Rotation as well, then it would have to be concluded that their performance superiority on visuo-spatial tasks has multiple causes. If it is only the effect of the Whole factor that distinguishes them from the other subjects, then we would be able to pinpoint a very specific reason for their islet of spatial ability.

7.3. Methods

7.3.1. Subjects

There were the same 5 groups of subjects as in the previous experiments. The composition of each group of subject was identical to that of experiment (2). The group details are summarized in Table 5.1 in Chapter (5).

7.3.2. Design and materials

The basic task modelled the classic Kohs' block paradigm. The subject was shown a two-dimensional pattern on a card and was required to construct a similar pattern always using four bricks. Four identical yellow and black one-inch cube bricks were used. Figure 7.1. shows an example of the basic task.

To investigate the effects of the various components of the task, the basic task was modified by drawing the designs such that they differed on one or more of the components in question. The basic task of the subject thus remained the same throughout, but the task demands, dictated by the type of design used, varied.

The designs were drawn as follows:-

1. The effect of whole gestalt of the shape was investigated by drawing the designs as either a whole or as four separate blocks. These designs will be referred to as Whole and Segmented.

2. The effect of the oblique contours present in the

Figure 7.1

EXAMPLE OF THE BASIC TASK

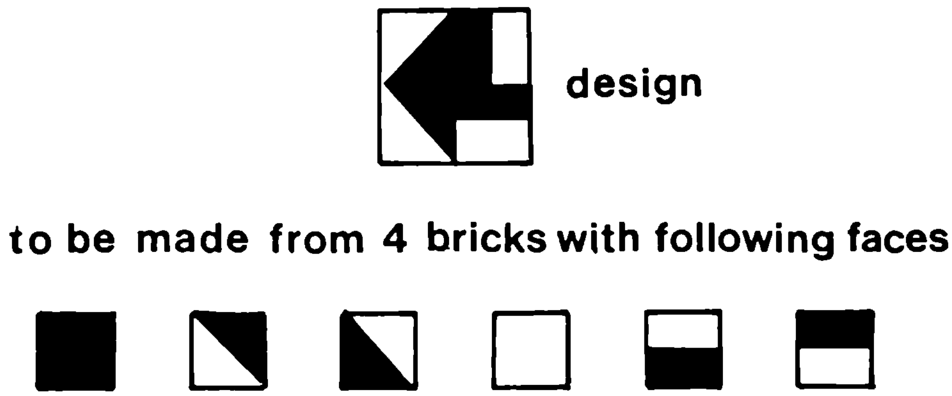
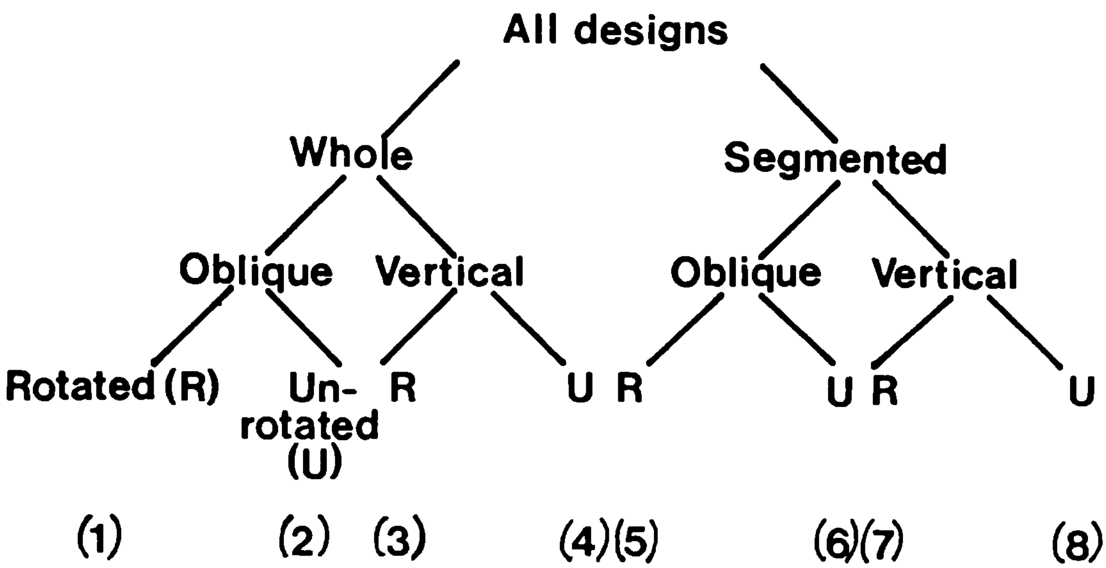


Figure 7.2

METHOD OF COMBINING THE 3 FACTORS



This method produced 8 sets of designs as follows:-

1. Whole Oblique Rotated designs
2. Whole Oblique Unrotated designs
3. Whole Vertical Rotated designs
4. Whole Vertical Unrotated designs
5. Segmented Oblique Rotated designs
6. Segmented Oblique Unrotated designs
7. Segmented Vertical Rotated designs
8. Segmented Vertical Unrotated designs

design was investigated by drawing the designs such that they had either oblique contours, or horizontal and vertical contours. These designs will be abbreviated as Oblique and Vertical from now on.

3. The effect of orientaton of the whole shape was investigated by drawing the designs as either rotated by 45 degrees such that the outline formed a diamond shape, or as unrotated such that the outline was a square shape. These designs will be referred to as Rotated and Unrotated from now on.

The designs were grouped into sets such that each of the three component factors were combined with each other evenly. The method of combining the three factors is illustrated in Figure 7.2.

The designs were drawn individually on two inch square white cards. There were 5 designs in each set, making a total of 40. There were three additional designs for demonstration.

Each of the 8 sets of designs used is shown in Figures 7.3(a) to 7.3(h).

7.3.3. Procedure

Each subject was tested individually. The subject was given a rectangular piece of cardboard to work on. The card with the design was also placed on a similar piece of cardboard. This was to provide an identical background for input and output. First, the subject was shown the four bricks and was told that all four were the same, that is, they all had one side that was yellow, one side that was

Figure 7.3 (a)

WHOLE OBLIQUE ROTATED DESIGNS

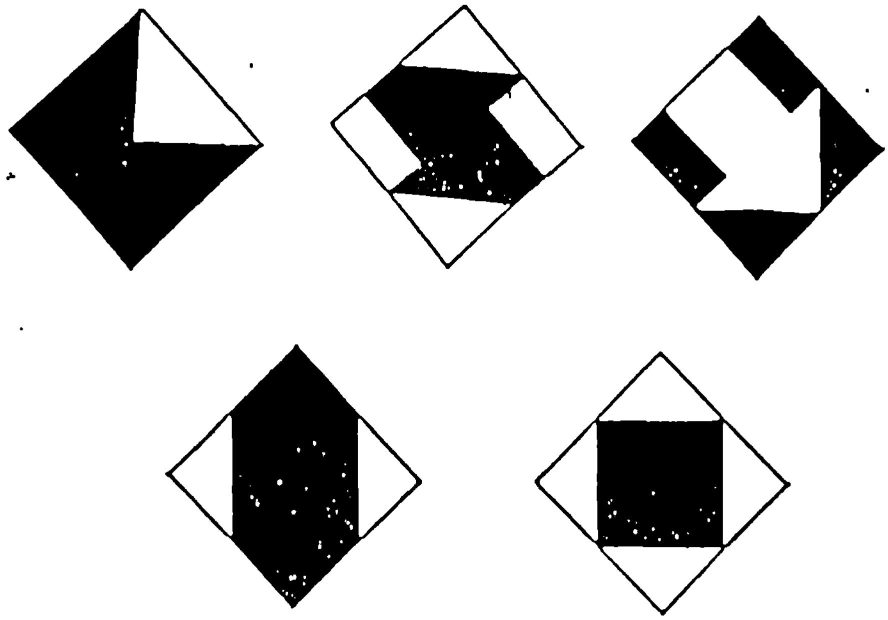


Figure 7.3 (b)

WHOLE OBLIQUE UNROTATED DESIGNS

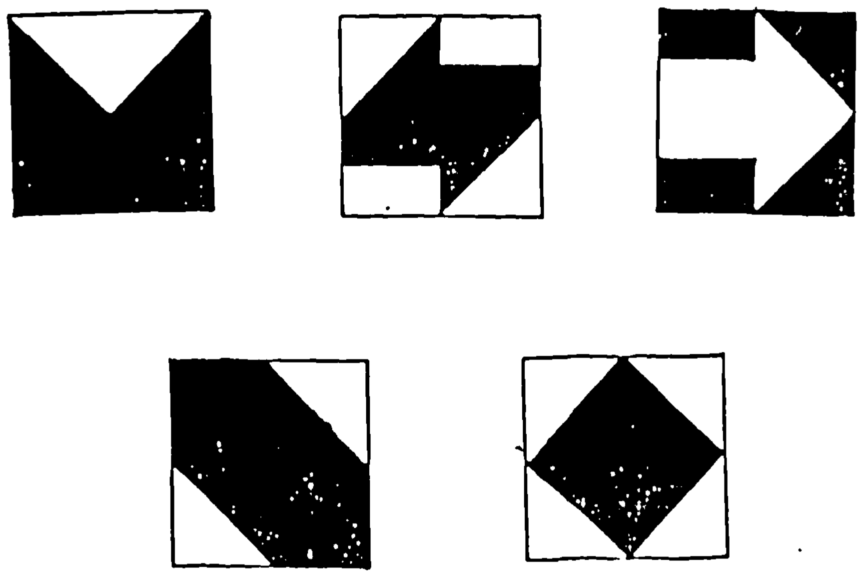


Figure 3(c)

WHOLE VERTICAL ROTATED DESIGNS

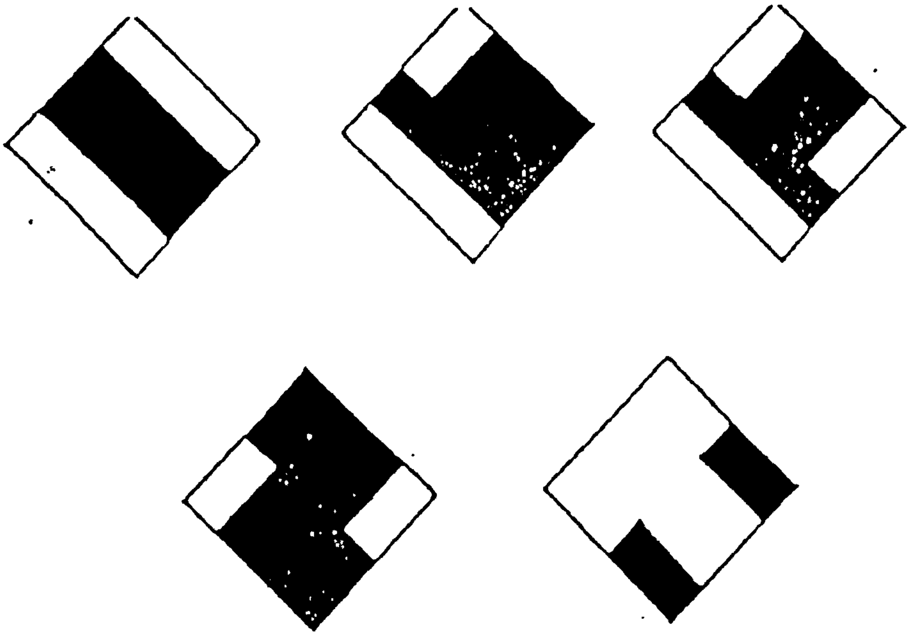


Figure 3(d)

WHOLE VERTICAL UNROTATED DESIGNS

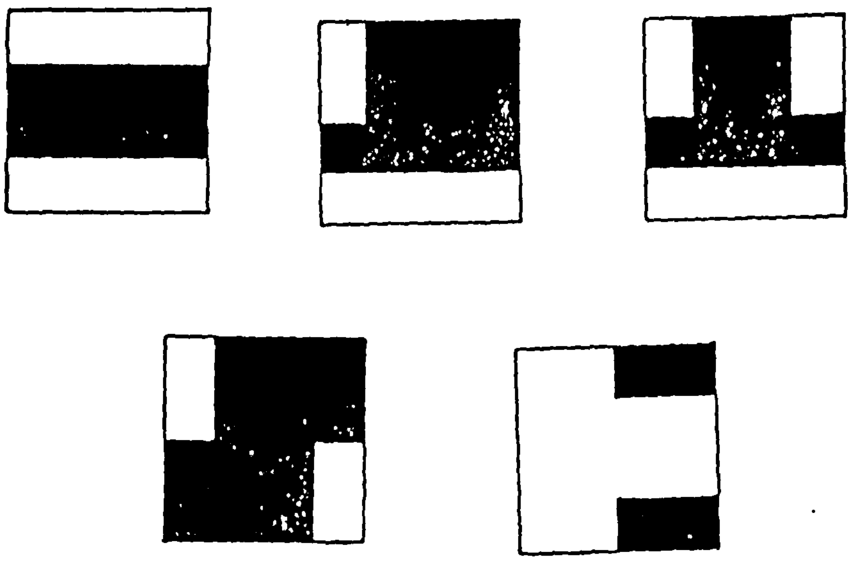


Figure 7.3(e)

SEGMENTED OBLIQUE ROTATED DESIGNS

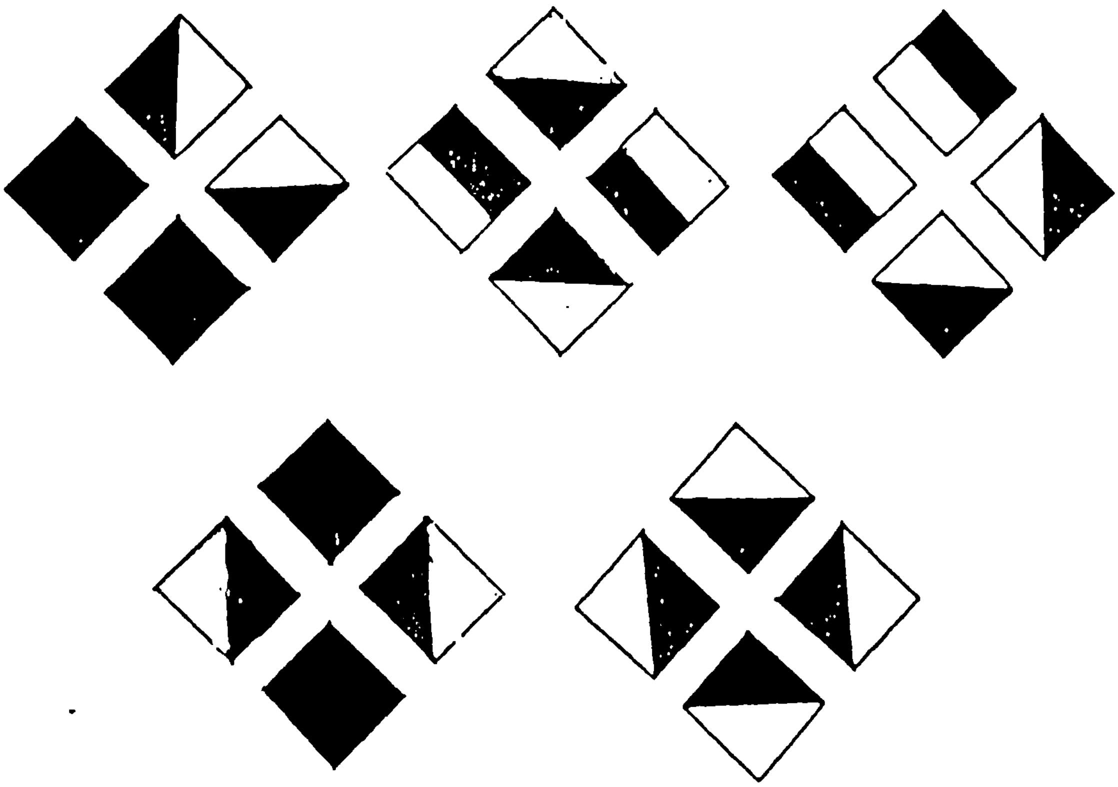


Figure 7.3(f)

SEGMENTED OBLIQUE UNROTATED DESIGNS

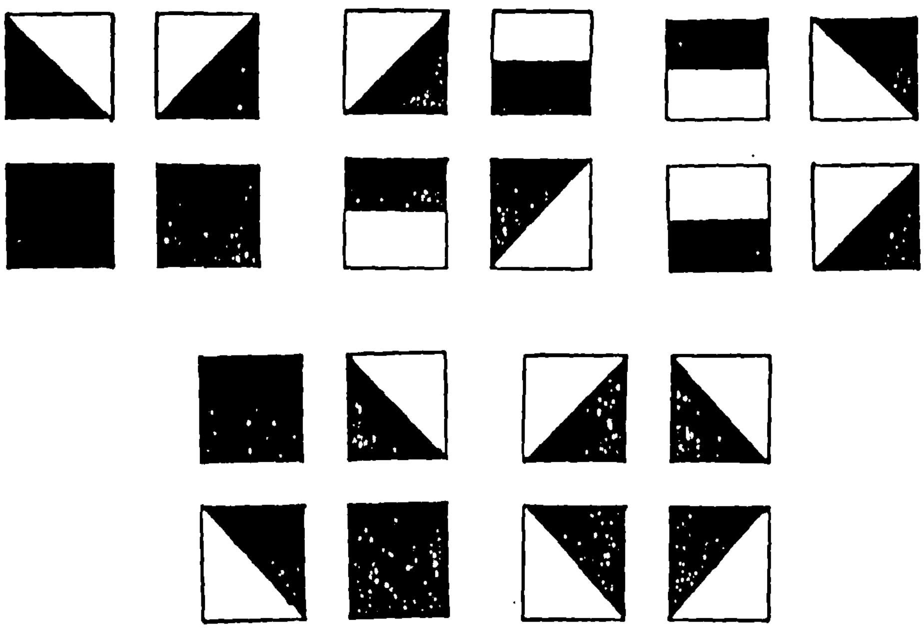


Figure 7.3(g)

SEGMENTED VERTICAL ROTATED DESIGNS

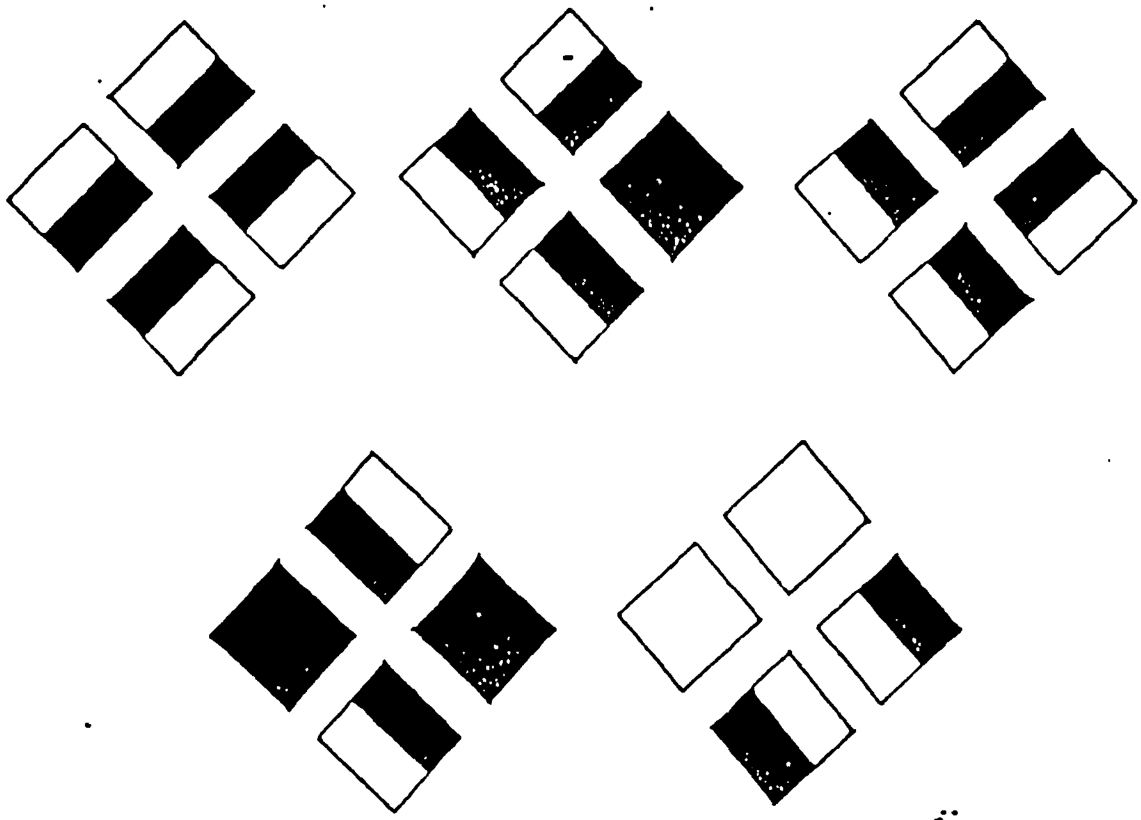
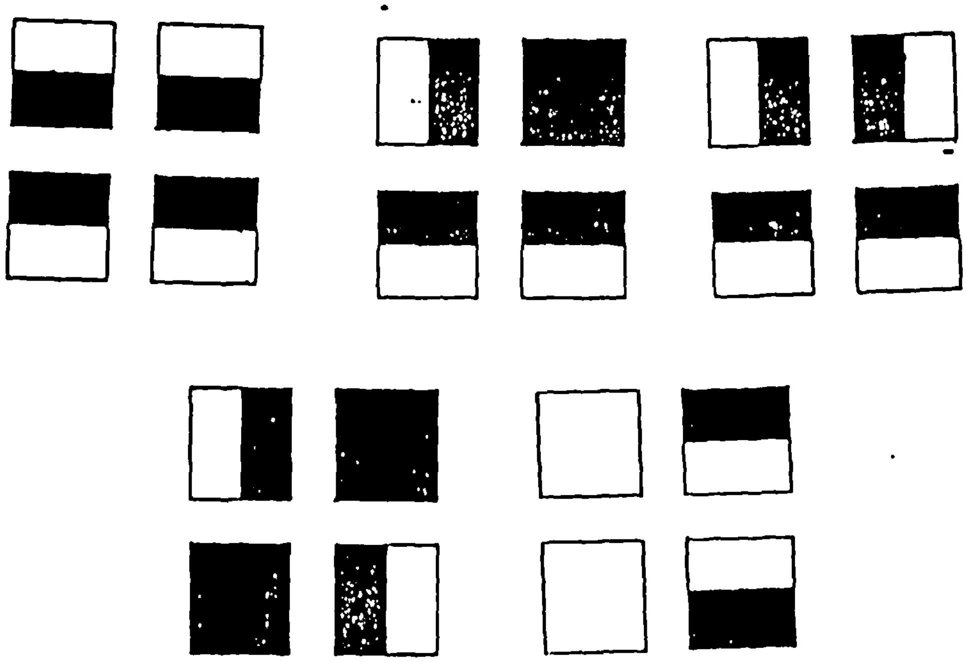


Figure 7.3(h)

SEGMENTED VERTICAL UNROTATED DESIGNS



black, two sides that were divided horizontally into yellow and black and two sides that were divided diagonally into yellow and black. The subject was then shown one of the demonstration designs and was asked to construct it with the bricks so that the the design on top of the bricks was the same as that on the card. If the subject failed to do so, the examiner constructed the pattern without much deliberation. The aim was to show the subject that the pattern on top of the bricks could be made up to match that on the card without giving hints as to how the subject might proceed. This was repeated for each of the three demonstration designs. The subject was asked to work as fast as possible.

The subject was then tested on each of the 8 sets, i.e. a total of 40 designs. After each trial, the examiner picked up the 4 bricks and dropped them back randomly. For each design, the examiner made notes about the way the subject was proceeding. When the subject finished constructing the design, the examiner recorded whether it was correct or not and the time taken in seconds. A maximum time-limit of three minutes was imposed. If the subject did not complete in this time, the next design was presented. The order of presentation of the sets was the same for all subjects and ensured that the segmemented designs were presented last.

7.4. Results

The accuracy levels, that is, the percentage of designs constructed correctly within the time allocated are shown in Table 7.1 for each set of designs for all 5 groups. As can be seen except for the Lower IQ Non-Autistic group, the accuracy levels of all the groups were extremely high.

TABLE 7.1.
Percentage Accuracy for each set of designs

SET	Average IQ Autistic (N=9)	Older Normal (N=17)	Lower IQ Autistic (N=9)	Younger Normal (N=16)	Lower IQ Non-Autistic (N=12)
1	100	99	96	96	62
2	100	100	100	99	75
3	100	100	100	100	90
4	100	100	100	100	92
5	100	100	100	100	98
6	100	100	100	100	100
7	100	100	100	100	100
8	100	100	100	100	100
Mean	100	98.5	99.5	99.4	89.6
SD	0	0.4	1.4	1.4	14.0

KEY: The following key which gives description of each set applies to the above table and tables 7.2 and 7.3

SET	DESCRIPTION
1	Whole Oblique Rotated designs
2	Whole Oblique Unrotated designs
3	Whole Vertical Rotated designs
4	Whole Vertical Unrotated designs
5	Segmented Oblique Rotated designs
6	Segmented Oblique Unrotated designs
7	Segmented Vertical Rotated designs
8	Segmented Vertical Unrotated designs

These are not particularly informative and will not be analyzed further. The following analysis concentrates on the time taken to construct the designs.

For each subject, the time taken for the 5 designs in each set were summed to give a total time (in seconds) for each set. The analysis below is based on these total scores. As the maximum time allowed was three minutes, the maximum possible time for a set was 900 seconds. It should be noted that the total time for each set includes the time taken for all designs, whether correct or not. For incorrect designs, this was the maximum time allowed , that is 180 seconds. On all the tables which follow, the time is given in seconds.

Tables 7.2 and 7.3 give the mean and standard deviations of the time taken for each set by each group. Individual subject data for each group is given in Appendix (6). A detailed inspection of the frequency distributions on each set by means of histograms and descriptive statistics revealed marked positive skewness for the majority of the sets for all the 5 groups, and a lack of homogeneity of variance between the different variables. Since the analysis of variance procedures to be used assumes an underlying normal distribution and a homogeneity of variance, a logarithmic transformation was applied to the raw data. An inspection of the frequency distributions of each variable on the transformed data showed that the majority of the distributions were much less skewed than before. All the statistical analyses reported below are on the transformed data. It should be noted that the data reported in the tables are the raw data as this is more meaningful.

TABLE 7.2
Means and SD of time taken (sec) for each set:
Average IQ Autistic and Older Normal groups

	Average IQ Autistic (N=9)		Older Normal (N=17)	
SET	Mean	SD	Mean	SD
1	106.3	(89.8)	101.8	(64.6)
2	67.4	(48.9)	78.5	(46.1)
3	43.9	(13.3)	52.8	(16.2)
4	39.6	(15.5)	51.0	(21.3)
5	46.9	(14.7)	46.6	(14.6)
6	41.2	(15.9)	37.3	(8.3)
7	37.9	(11.9)	39.2	(10.9)
8	36.1	(12.6)	33.6	(12.6)

TABLE 7.3
Means and SD of time taken (sec) for each set:
Lower IQ Autistic, Younger Normal and
Lower IQ Non-Autistic groups

	Lower IQ Autistic (N=9)		Younger Normal (N=16)		Lower IQ Non-Autistic (N=12)	
SET	Mean	(SD)	Mean	(SD)	Mean	(SD)
1	154.8	(84.3)	219.0	(100.0)	425.5	(323.0)
2	106.8	(59.3)	154.9	(74.8)	355.9	(232.4)
3	65.0	(25.9)	80.7	(24.1)	198.6	(231.9)
4	62.4	(29.8)	84.2	(41.5)	201.7	(197.4)
5	63.2	(23.9)	67.0	(14.4)	152.0	(95.9)
6	57.4	(18.1)	51.0	(14.8)	118.2	(170.4)
7	52.6	(18.6)	52.9	(16.8)	87.3	(31.8)
8	44.6	(14.4)	35.6	(6.4)	82.6	(124.5)

As in the previous experiments, the results were analyzed separately for each autistic group. Thus, the Average IQ Autistic group was compared with the Older Normal group of subjects. The Lower IQ Autistic group was compared with the Younger Normal group. The results of the Lower IQ Non-Autistic group were analyzed separately as there was ample evidence that the task difficulty of the block design task was much greater for this group. As discussed in Chapter (4) the IQ profile analysis of this group showed that they had particular difficulty with the block design task. The accuracy levels reported above and the mean time taken for each set both indicate that the basic task itself was much more difficult for this group than for any of the other groups.

The results were analyzed by means of a 3 factor multivariate analysis of variance (MANOVA) (Hand and Taylor,1987). The three main factors were Whole, Oblique and Rotation each split into 2 levels as shown in Figure 7.2. The design , thus, was a 2 X 2 X 2 for repeated measures.

a. Average IQ Autistic and Older Normal groups

A summary of the MANOVA for these two groups is shown in Table 7.4. This reveals that none of the between group interaction effects are significant, except for the interaction between Whole X Group which is marginally significant ($P<.06$) at the two-tailed level. In fact, since the direction of this effect was predicted, one-tailed probability is in order. This means we can treat the interaction effect as significant. This interaction suggests that the main effect of Whole is different for each

TABLE 7.4.
Summary MANOVA: Average IQ Autistic and Older Normal groups**

SOURCE	MEAN SS	DF	F	PROB.
Group	0.45	8,17	1.7	ns
Whole	1.90	*	71.53	.001
Whole X Group	0.09	*	3.70	.06
Oblique	1.12	*	74.22	.001
Oblique X Group	0.01	*	0.63	ns
Rotation	0.28	*	28.65	.001
Rotation X Group	0.002	*	0.02	ns
Whole X Oblique	0.31	*	29.79	.001
Whole X Oblique X Group	0.003	*	0.30	ns
Whole X Rotation	0.002	*	0.34	ns
Whole X Rotation X Group	0.02	*	2.71	ns
Oblique X Rotation	0.04	*	8.52	.01
Oblique X Rotation X Group	0.003	*	0.65	ns
Whole X Oblique X Rotation	0.18	*	3.43	.07
Whole X Oblique X Rotation X Group	0.001	*	0.19	ns

*The Degrees of freedom for the univariate F-tests for these effects are (1,24)

** N for Average IQ Autistic group = 9
N for Older Normal group = 17

group. The only other significant effects are the two-way interactions of Whole X Oblique and of Oblique X Rotation. These suggest that the effects of the Whole are interdependent with the Oblique factor, and the effects of the Oblique are interdependent with the Rotation factor. The 3-way interaction effect of Whole X Oblique X Rotation just misses significance ($p<.07$).

(1) <u>The WHOLE X GROUP interaction</u>

This interaction is illustrated in Figure 7.4. This indicates that the difference in time taken to construct Whole versus Segmented sets is significantly greater for the Older Normal group compared to the Average IQ Autistic group. Thus, as predicted, the performance of the Average IQ Autistic group is significantly less affected by the Whole.

For illustrative purposes only, Figure 7.5 shows the effects of Whole for each factor separately. The time taken for each pair of Whole and Segemented sets is shown for:

a. designs without any other factor;

b. designs with Oblique factor only;

c. designs with Rotation factor only;

d. designs with both Rotation and Oblique factors;

However, it must be remembered that the 4-way interaction was not significant. Figure 7.5 illustrates that the difference in time between Whole and Segmented designs varies (non-significantly) as a function of the number and type of the other factors present. It should be noted that for all the four combinations, the time taken on Segmented sets remains constant. It is the time taken to construct Whole designs that tends to increase as the complexity increases.

Figure 7.4

WHOLE X GROUP INTERACTION: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS

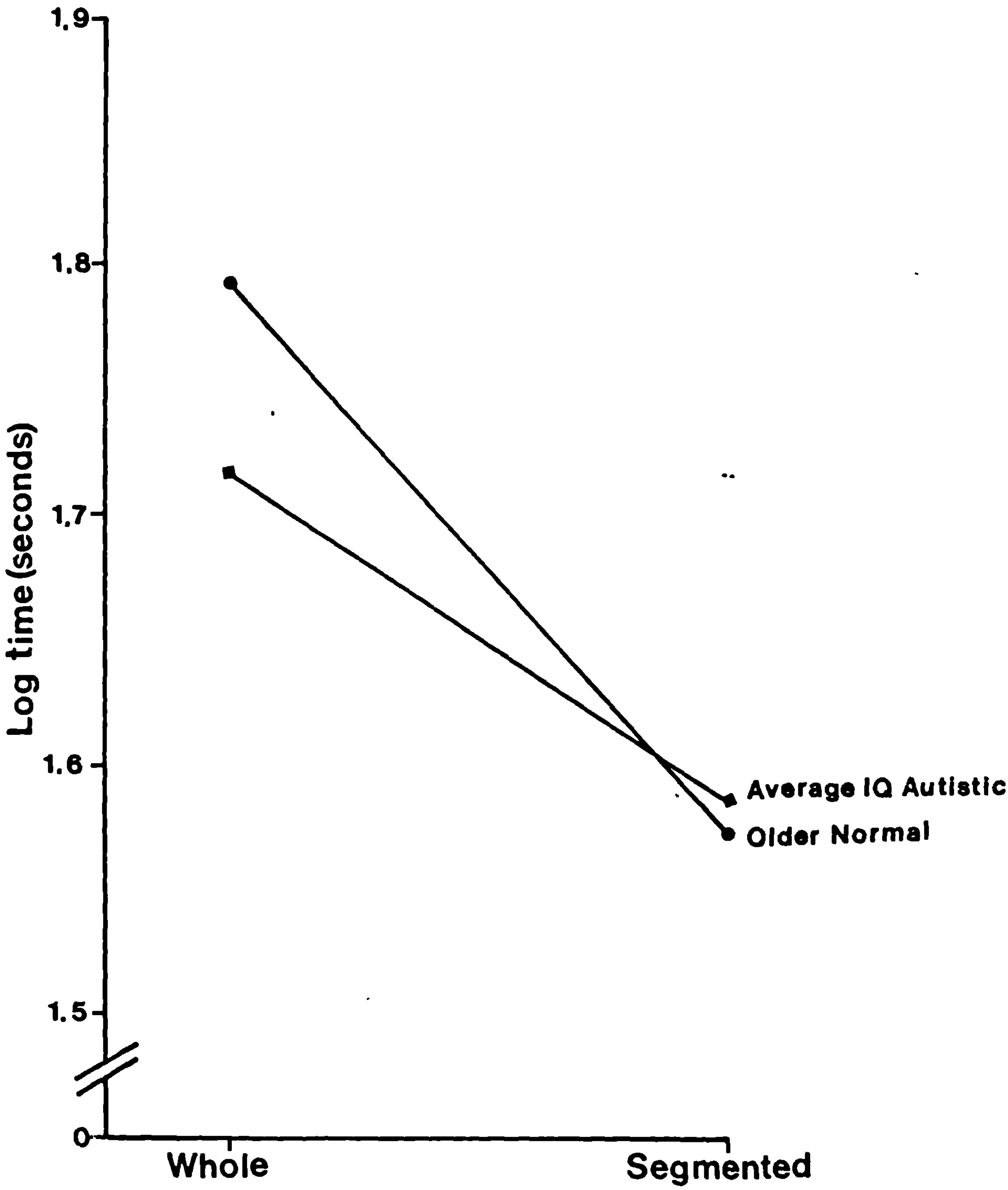
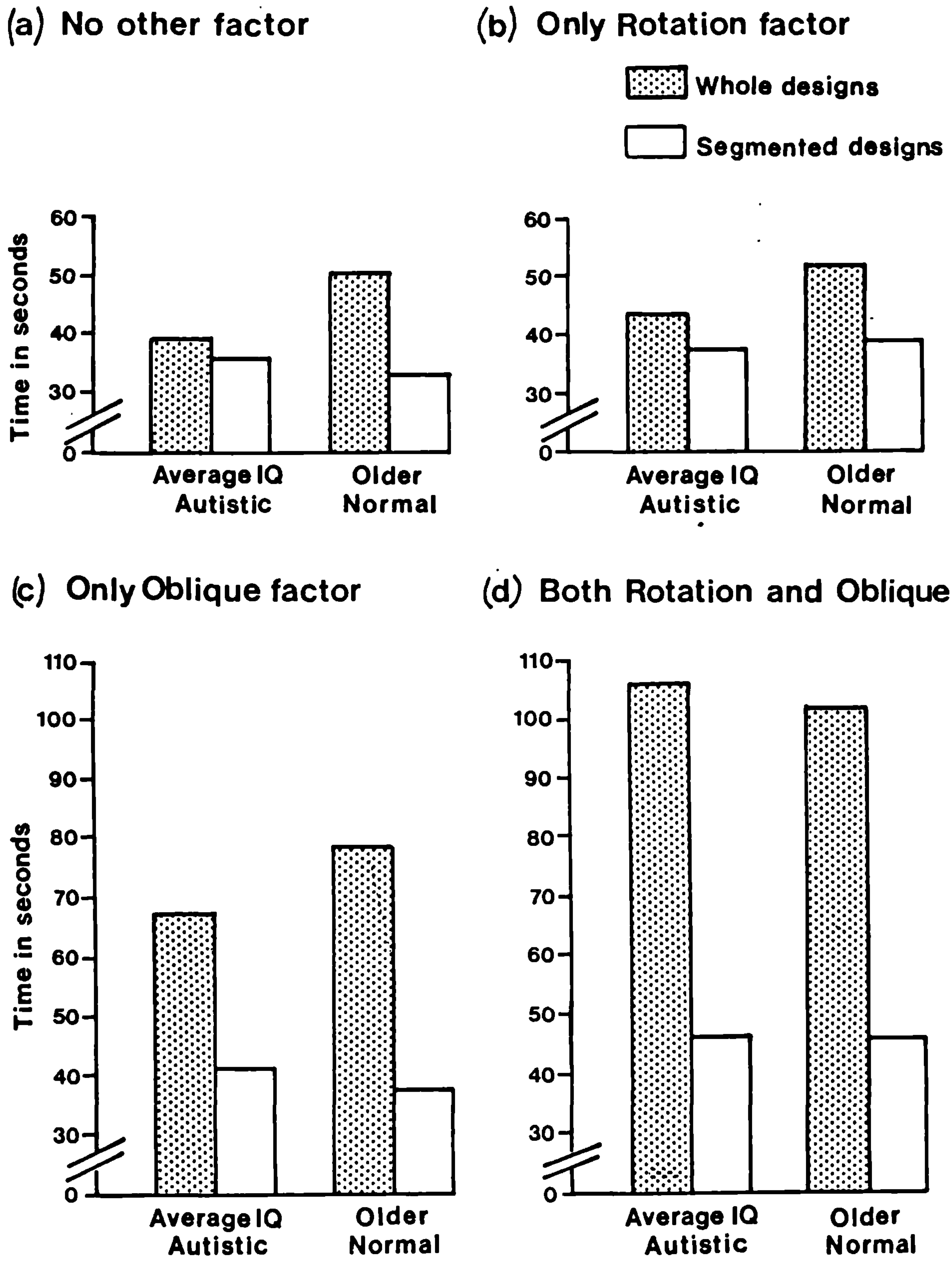


Figure 7.5

TIME TAKEN (SECONDS) FOR WHOLE AND SEGMENTED DESIGNS
: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS



These results indicate that the general pattern of effects of the different combination of factors is similar for both groups: the important and significant result is that, taken overall, the Average IQ Autistic group shows less of a detrimental effect of Whole designs.

(2) The effect of the OBLIQUE and the ROTATION factors

The nearly significant 3-way interaction and the highly significant 2-way interaction effects between the factors indicate that the Oblique and Rotation factors both have a detrimental effect on the performance of all subjects on the block design task.

Figure 7.6 illustrates the interaction effect of Whole X Oblique. This indicates clearly that the presence of the Oblique has a detrimental effect on Whole designs but not on Segmented designs.

Figure 7.7 illustrates the interaction effect of Oblique X Rotation. Rotated designs take significantly longer to construct than Unrotated designs only when the Oblique factor is included. Rotation does not have a significant effect on designs without the Oblique.

All the results taken together suggest that the Whole has the greatest effect on construction of the block designs. It is only here that group differences emerge. The Oblique has an intermediate effect, and the Rotation factor has the smallest effect. Nevertheless, all three factors contribute to task difficulty, and interact with each other.

b. Lower IQ Autistic and Younger Normal group

A summary of the MANOVA for these two groups is given in Table 7.5. The results are very similar to those

Figure 7.6

WHOLE X OBLIQUE INTERACTION: AVERAGE IQ AUTISTIC AND OLDER NORMAL GROUPS

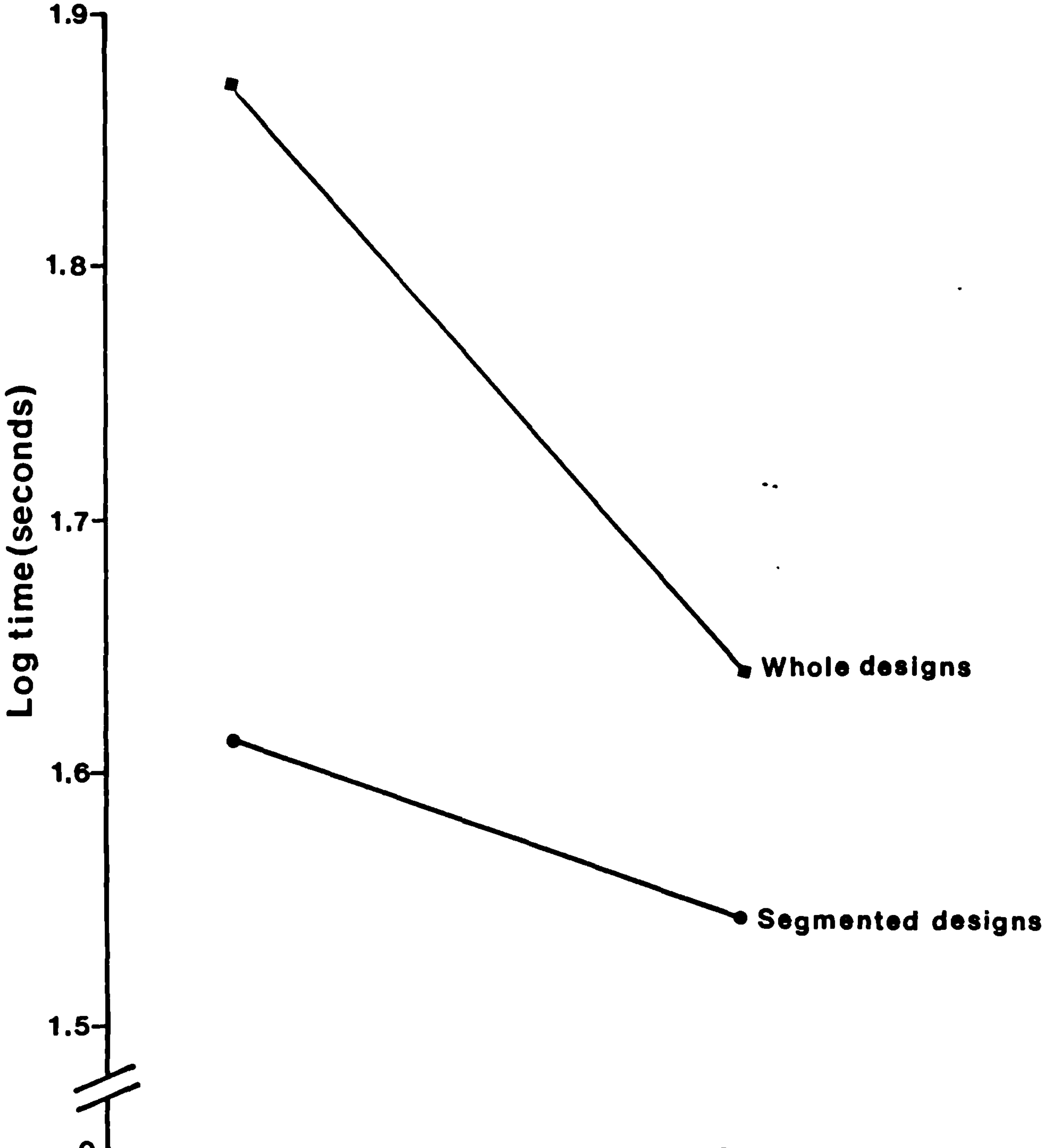


Figure 7.7

OBLIQUE X ROTATION INTERACTION: AVERAGE IQ
AUTISTIC AND OLDER NORMAL GROUPS

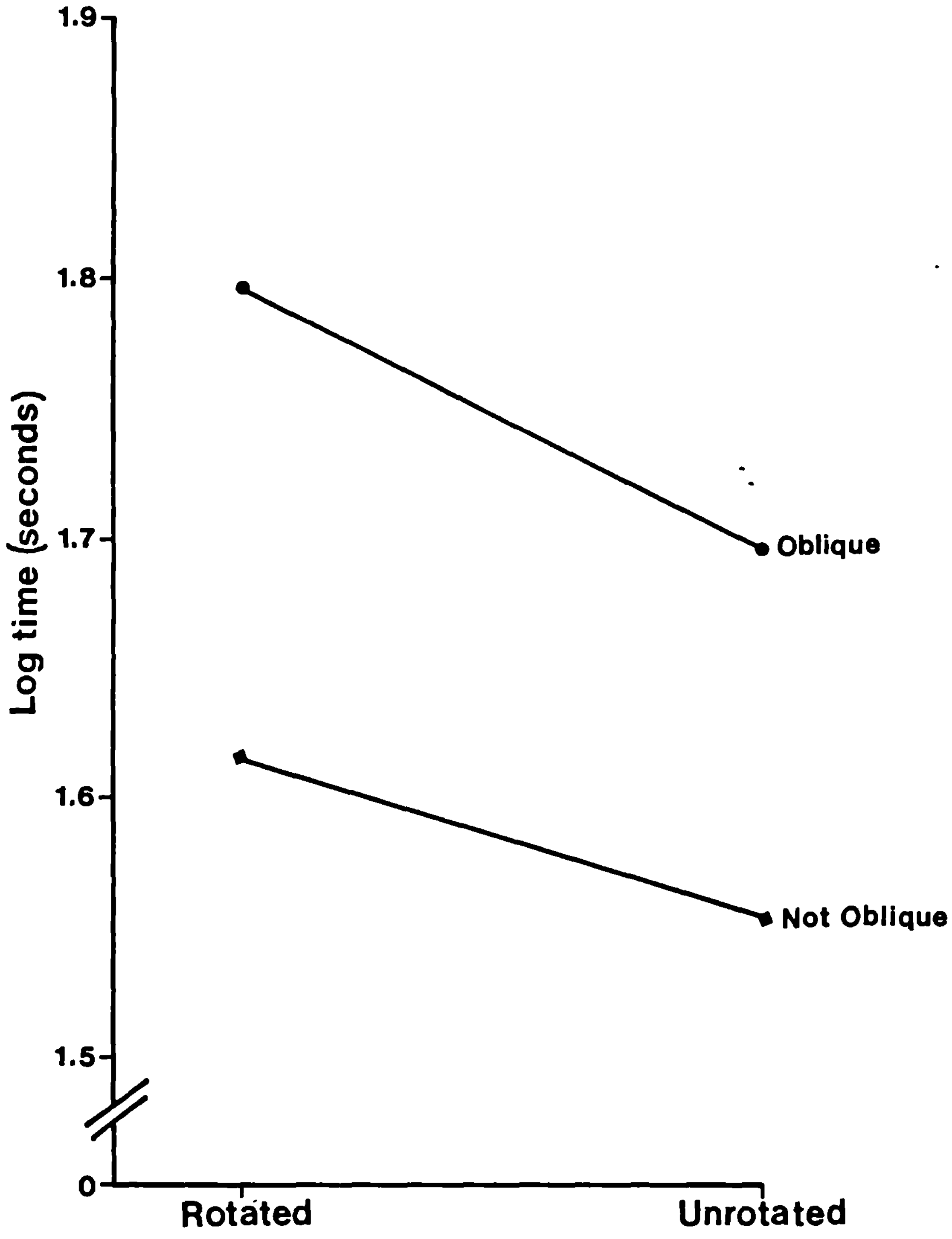


TABLE 7.5
Summary MANOVA: Lower IQ Autistic and Younger Normal groups**

SOURCE	MEAN SS	DF	F	PROB.
Group	0.58	8,16	2.7	.05
Whole	4.76	*	199.6	.001
Whole X Group	.300	*	12.58	.01
Oblique	2.33	*	134.75	.001
Oblique X Group	.020	*	1.13	ns
Rotation	.457	*	31.06	.001
Rotation X Group	.019	*	1.31	ns
Whole X Oblique	.498	*	33.51	.001
Whole X Oblique X Group	.000	*	.015	ns
Whole X Rotation	.008	*	0.61	ns
Whole X Rotation X Group	.033	*	2.43	ns
Oblique X Rotation	.037	*	3.2	ns
Oblique X Rotation X Group	.000	*	.020	ns
Whole X Oblique X Rotation	.104	*	7.72	.01
Whole X Oblique X Rotation X Group	.000	*	.009	ns

*The degrees of freedom for the univariate F-tests these effects are (1,23)

** N for Lower IQ Autistic group = 9
N for Younger Normal group = 16

described above. The between-group interaction effects were non-significant except for the Whole X Group interaction. The 3-way interaction effect of Whole X Oblique X Rotation (which previously just missed significance) was significant. This indicates that the effects of all 3 factors are inter-dependent.

(1) <u>The WHOLE X GROUP interaction</u>

The between-group interaction effect of the Whole factor is illustrated in Figure 7.8. This shows that the overall effect of Whole is significantly less for the Lower IQ Autistic group than the Younger Normal group.

To illustrate the effect of the Whole at the different levels, the mean time taken for each type of Whole and Segmented sets of designs are represented as histograms in Figure 7.9. using raw scores. This figure shows that for both the groups the effect of the whole is similar on all conditions, but the Lower IQ Autistic group shows a smaller effect throughout. The pattern of results for these two groups is very similar to that described above for the Average IQ Autistic group and the Older Normal group: The difference in time taken to construct Whole and Segmented designs tends to increase with the complexity of the designs. However, in every condition, the difference between Whole and Segmented sets was larger for the Younger Normal group than for the Lower IQ Autistic group.

As for the Average IQ group, the important and significant finding is that taken overall, the Whole has less effect on the performance of the Lower IQ Autistic group.

Figure 7.8

WHOLE X GROUP INTERACTION: LOWER IQ AUTISTIC AND YOUNGER NORMAL GROUPS

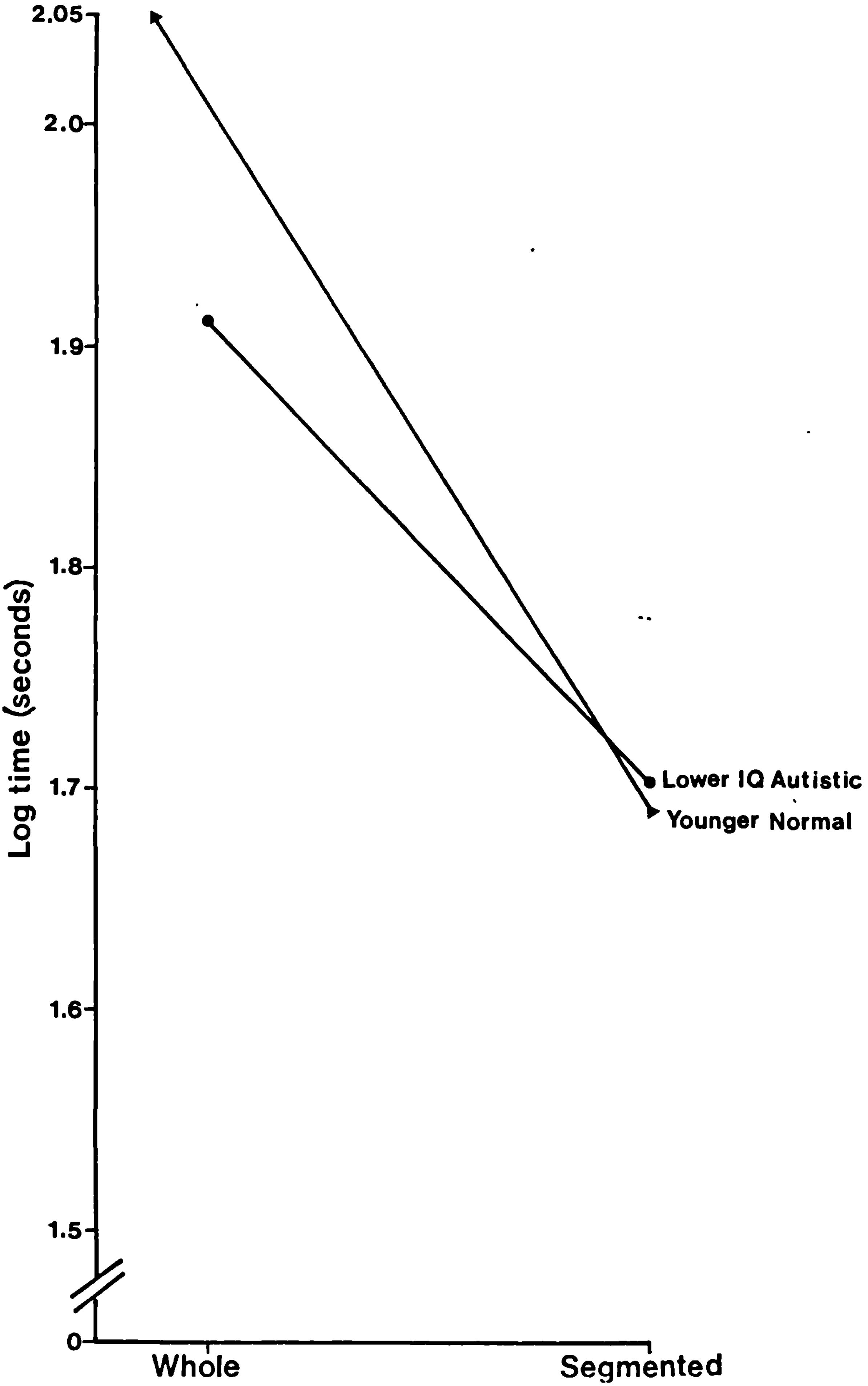


Figure 7.9

TIME TAKEN (SECONDS) FOR WHOLE AND SEGMENTED DESIGNS: LOWER IQ AUTISTIC AND YOUNGER NORMAL GROUPS

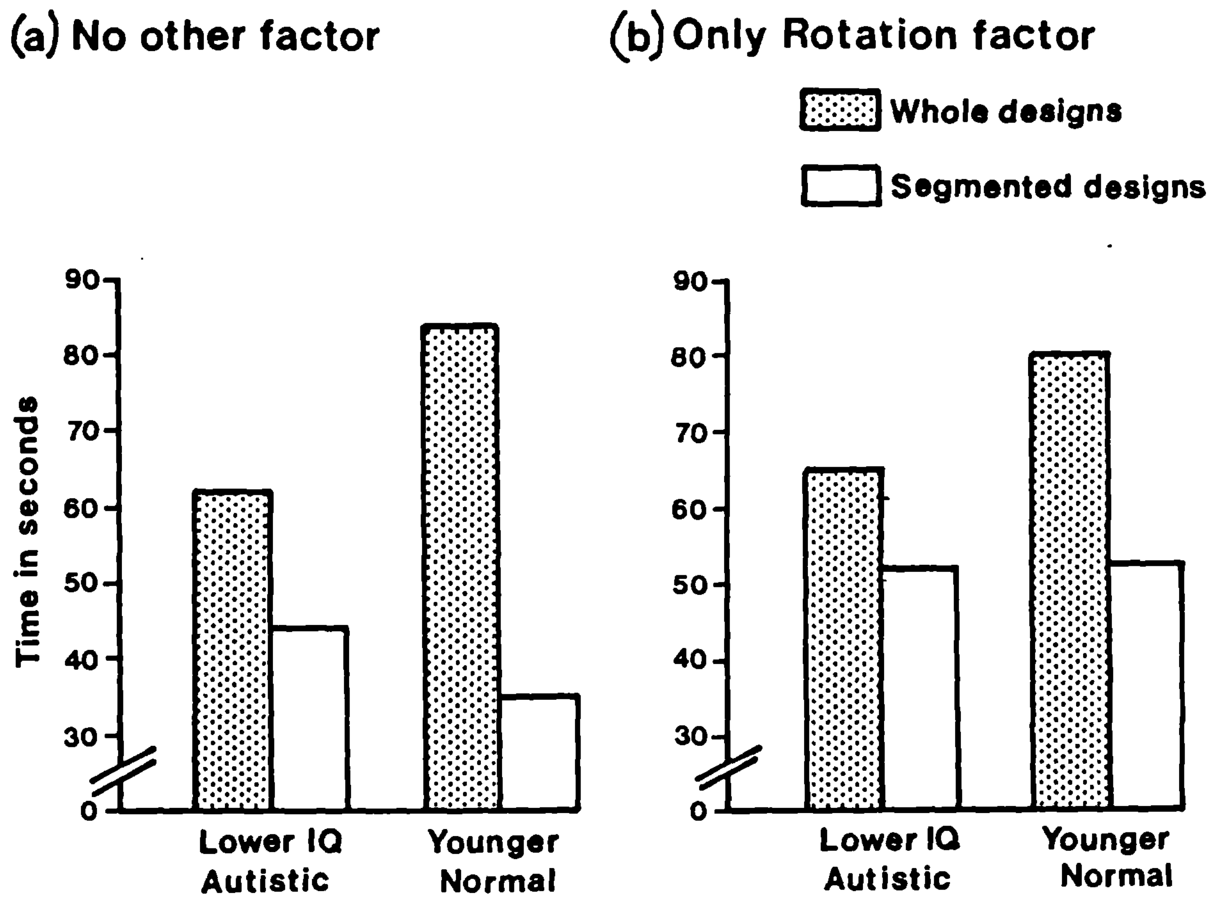
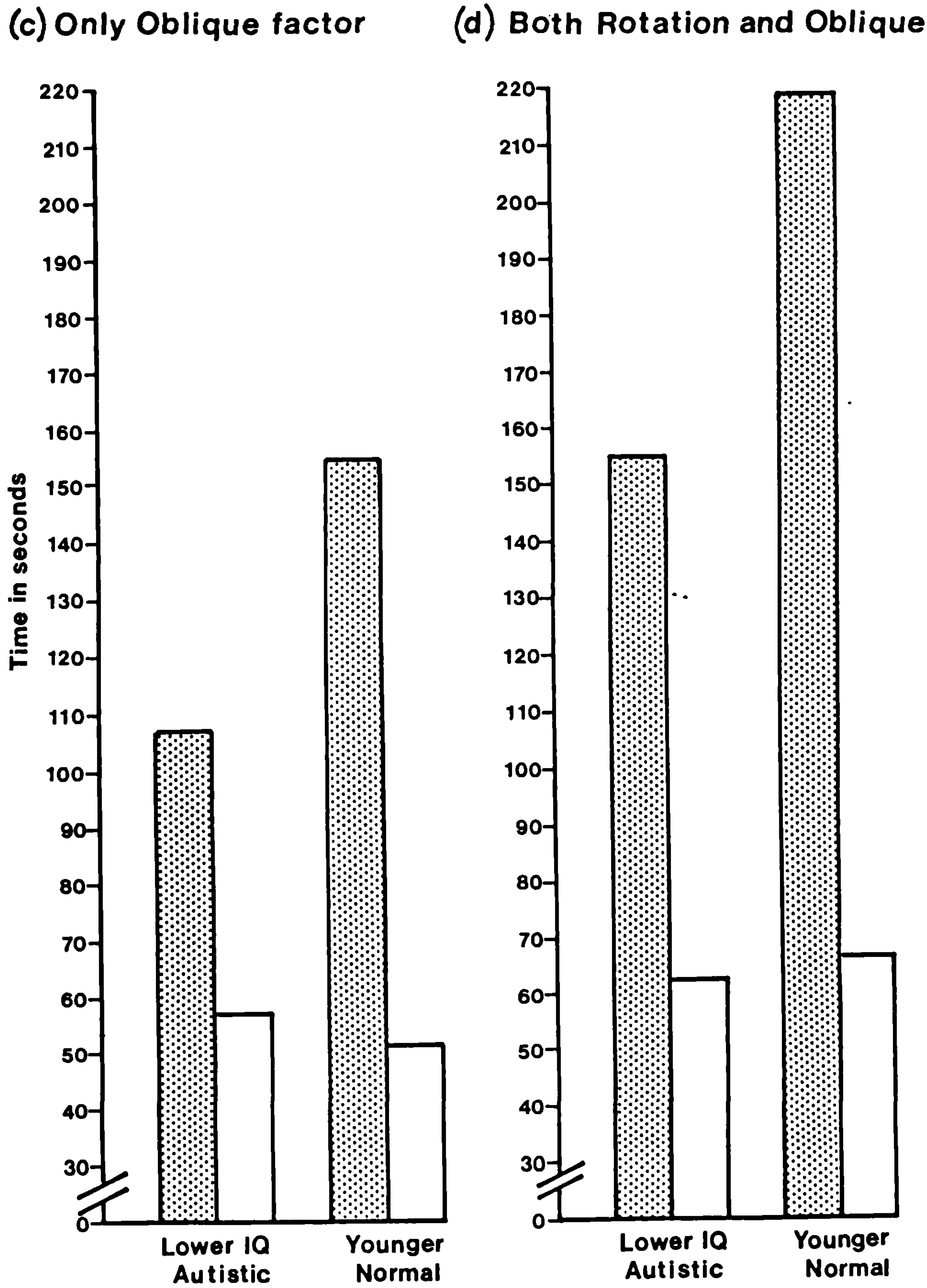


Figure 7.9 (cont)



(2) <u>The effects of the OBLIQUE and ROTATION factors</u>

The 3-way interaction for these two groups is illustrated in Figure 7.10. This shows how the three factors are inter-dependent. The Oblique has a negligible effect on Segmented designs compared to Whole designs. On Whole designs, the effect of the Oblique is greater when the Rotation factor is included as well. Overall, the effect of the Oblique is much greater than the effect of the Rotation.

c. Lower IQ Non-Autistic group

The results of this group are treated separately because their error rates and time taken to construct the designs were much higher than for any other group. In a study like this which is set out to investigate diferences in strategies, it is important that the groups being compared are matched on basic task difficulty.

A summary of the MANOVA for the Lower IQ Non-Autistic group is given in Table 7.6. The only significant interaction effect was that between Whole X Rotation. This was only just significant at the 5% level. The main effects of Whole and of Oblique were highly significant, but the main effect of Rotation was not significant. These results indicate that for this group, unlike the other groups, the three factors are not strongly inter-related.

Figure 7.11 illustrates the main effects of each factor. This indicates clearly that the Whole and Oblique factors have a very detrimental effect on the performance of this group. However, the effect of the Rotation as a factor on its own is negligible. The interaction effect of Whole X Rotation, plotted in Figure 7.12, indicates that the effect of the Rotation factor, though small, is significantly

Figure 7.10

WHOLE X OBLIQUE X ROTATION INTERACTION: LOWER IQ AUTISTIC AND YOUNGER NORMAL GROUPS

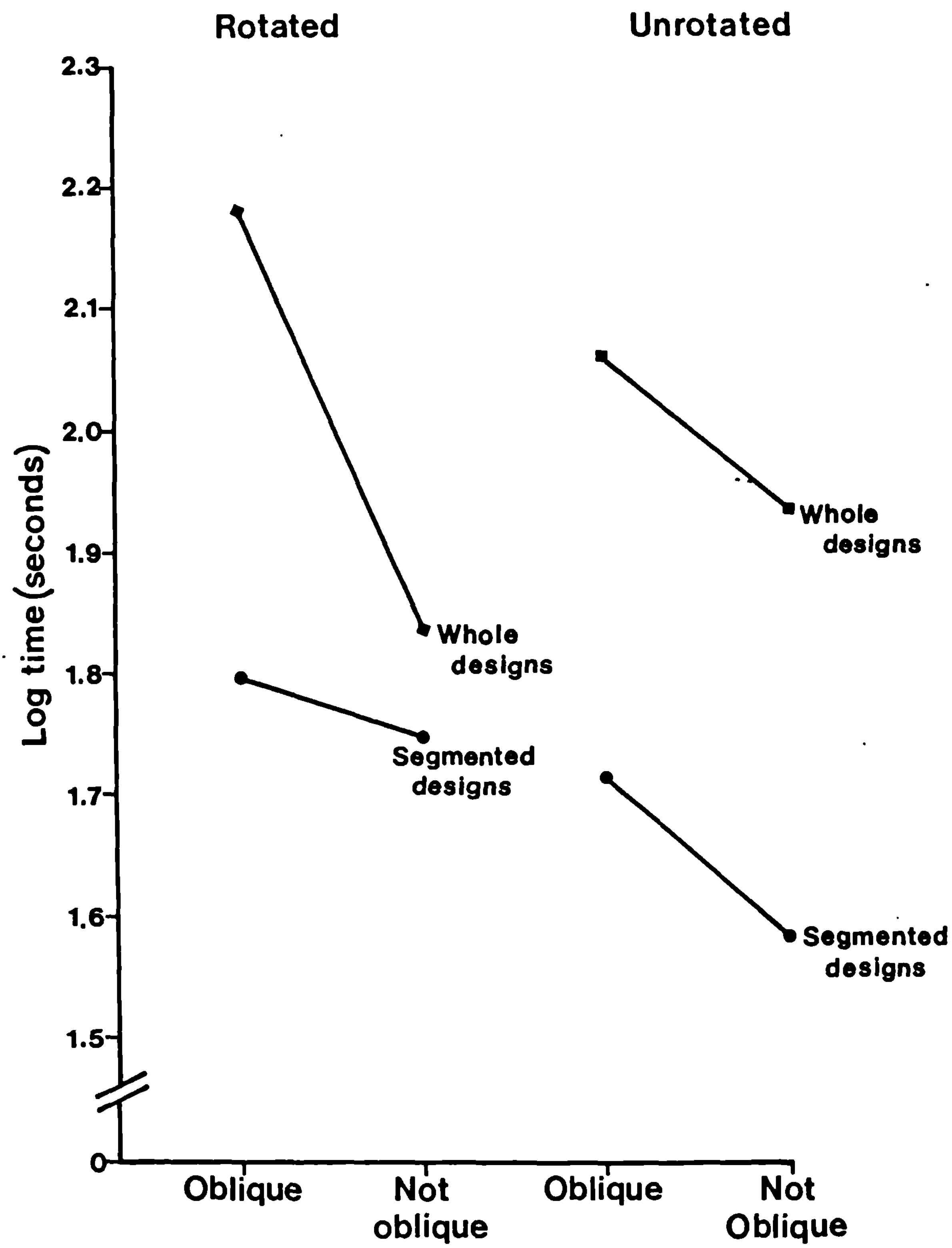


TABLE 7.6
Summary MANOVA: Lower IQ Non-Autistic group (N = 12)

SOURCE	MEAN SS	DF*	F	PROB.
Whole	4.007		12.82	.01
Oblique	1.46		14.56	.01
Rotation	0.17		2.44	ns
Whole X Oblique	0.05		1.37	ns
Whole X Rotation	0.16		5.04	.05
Oblique X Rotation	0.03		1.77	ns
Whole X Oblique X Rotation	0.1		0.47	ns

*The degrees for freedom for the univariate F-test for all the above effects are (1,11)

Figure 7.11

EFFECT OF EACH FACTOR: LOWER IQ NON-AUTISTIC GROUP

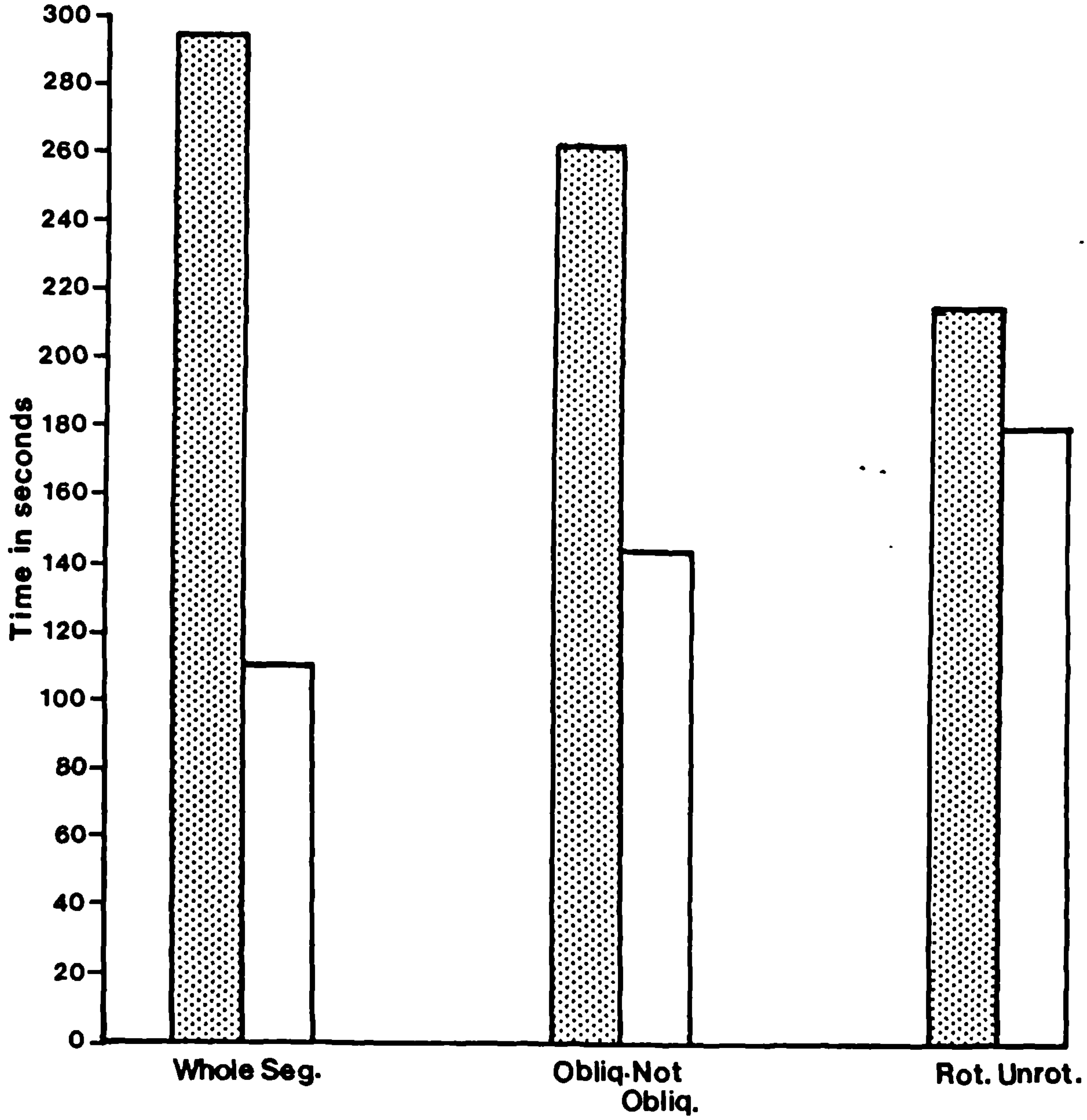
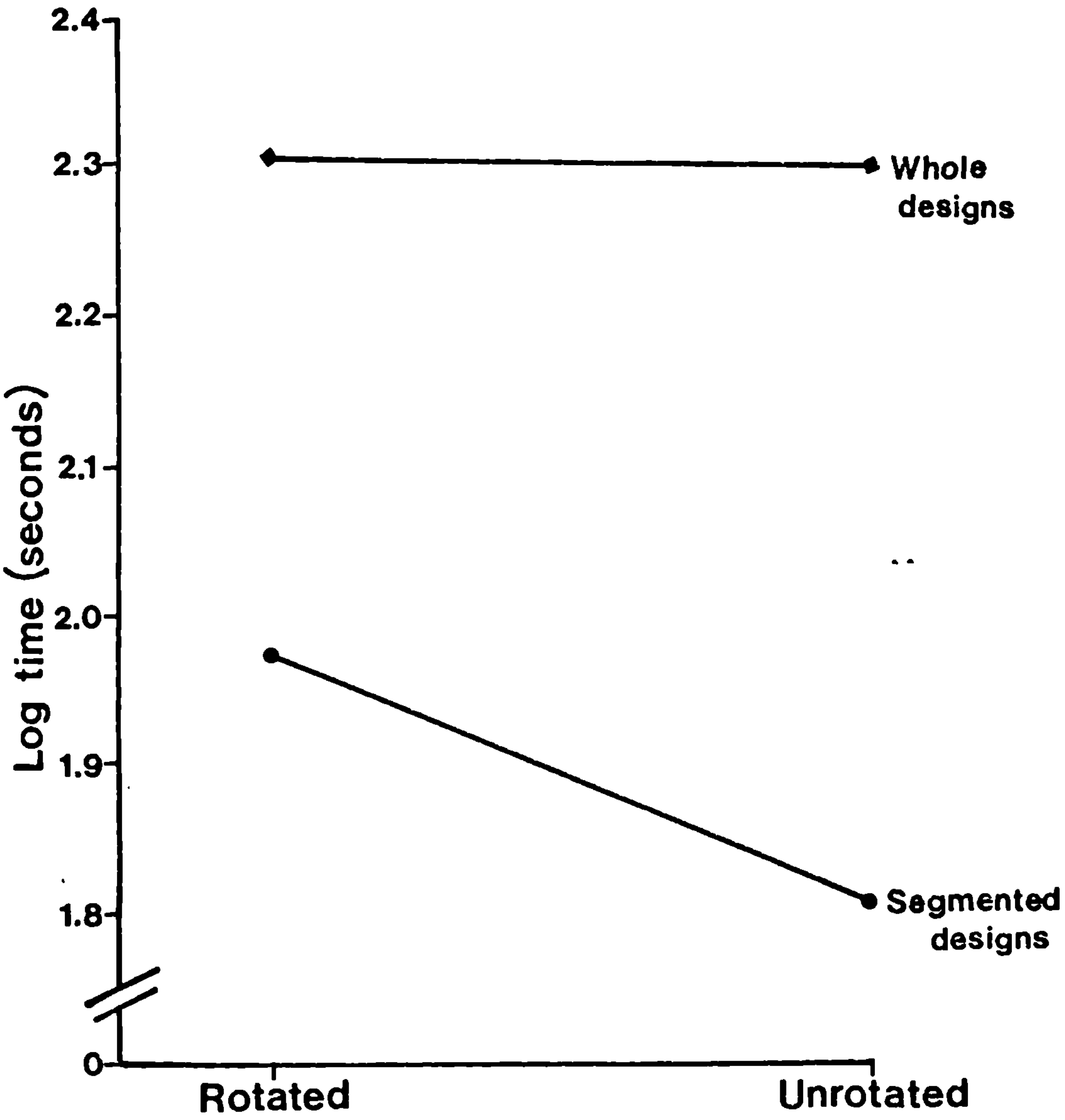


Figure 7.12

WHOLE X ROTATION INTERACTION: LOWER IQ

NON-AUTISTIC GROUP



more on Whole designs than on Segmented designs.

7.5. Discussion

The aim of this experiment was to identify specific cognitive components which may explain the superior performance of autistic people on the block design and other visuo-spatial tasks. Three possible component factors were identified and the effects of each of these on block design performance were investigated. The factors were: a) the ability to break up the Whole; b) the ability to perceive and reproduce oblique contours within the design; and c) the ability to construct rotated designs.

A particular prediction was made for only one of these, namely, the overall effect of the Whole. It was hypothesized that this effect would be less marked for autistic subjects and that this would be a major reason for their performance superiority on the block design task. This prediction was confirmed. For both the autistic groups, the effect of the Whole was significantly less marked than for their respective normal control groups. Furthermore, this was the only effect that discriminated the autistic groups from the control groups. For the normal groups, on the other hand, the difference between the time taken to construct Whole and Segmented designs was large and suggests that the Whole is difficult to break up and is a cause of the task difficulty. Physical segmentation, as provided experimentally on the Segmented sets, had a beneficial effect.

The hypothesis that autistic groups would not be adversely affected by the gestalt qualities of the design, which makes the breaking up difficult for normal people, was based on previous findings regarding their ability to locate embedded figures (Shah & Frith, 1983). Although the present block design task and the embedded figures tasks are different, the underlying cognitive requirement for effective performance on both tasks is the same. In both the tasks, the tendency to see the Whole only has to be resisted and the Whole has to be mentally broken into its constituent elements. The present findings lend additional support for the hypothesis that autistic people are able to break up the gestalt in the immediate perception more easily than control groups of normal subjects.

The results indicated that the factors of Oblique and Rotation also had strong effects on the performance of all groups. On these factors, both of which are aspects of visuo-spatial abilities, the autistic groups were not differentiated from their control groups. In general, the designs containing the Oblique slowed down performance. Designs which were merely rotated by 90 degrees were not much more difficult than unrotated designs. When designs containing obliques were rotated and segmentation was not provided, performance was at its lowest level. When the designs were pre-segmented , the effects of the Oblique and and Rotation factors were slight. This suggests that the presence of the Oblique and the Rotation factors increases task difficulty by making the mental segmentation more difficult.

All the results taken together show that, apart from segmentation ability, all the groups show a very similar effect of Oblique and Rotation, although there are differences in quantitative terms, i.e. in the magnitude of the effects. The similarity in the pattern of effects of all the factors across groups which differ markedly in overall block design performance suggests that the components identified and investigated here are critically involved in block design performance. The results discussed above can be used to give a thorough analysis of the block design task and identify the relevance of each component in contributing to the ease or difficulty on this task.

First, without doubt, the ability to overcome the tendency to see the Whole and to mentally segment the design into four component blocks is crucial to effective and accurate task performance. All the other factors are secondary to this major hurdle which has to be overcome. The presence of the oblique contours and the rotation of the design affects performance by making the segmentation more difficult. The results discussed above suggest that the reason that the the block design task is relatively easy for the autistic subjects and represents an islet of normal ability or super-normal ability is the abnormal ease of segmentation in autistic groups. By contrast, the block design task is one that the Lower IQ Non-Autistic group perform poorly on. For this group, the absence of segmentation is a major source of difficulty even with the simplest designs. When segmentation is provided experimentally for them, that is on the Segmented designs, there is a dramatic improvement in their performance. For the two normal groups, segmentation that is artificially provided is very helpful but does not affect performance to the same extent as that of the Lower IQ Non-Autistic group.

For all subjects, the presence of oblique contours presents difficulty if segmentation is not provided. One possible reason is that segmentation has to be made by dissecting the pattern vertically and horizontally. This is because the little cubes have such outlines and are to be used as elements of construction. On the designs which include Oblique contours, the segmentation has to be made against this trend as there are no or few horizontal or vertical contours in the design against which the imaginary lines of segmentation can be matched. By contrast , the designs without the Oblique contain only vertical and horizontal contours. The lines of segmentation can be easily matched and compared with these. This corroborates the findings of Huttenlocher (1967) and Bryant (1974) discussed in the introduction to this experiment. According to these results, the difficulty of the Oblique is due to the fact that usually there are no contours in the immediate external environment to which it can be compared.

The rotation of the design does not affect the performance on the block design task unless the designs are whole and contain oblique contours. Thus, Whole designs with vertical and horizontal contours only are not affected. These results provide additional support for the reason discussed above as to why the Oblique makes segmentation difficult. It was suggested that segmentation is easier when the contours within the design are similar in orientation to the imaginary lines of the mental segmentation. This relationship does not change whether the designs are rotated or not. This becomes clearer if we consider what happens to the contours when the design is rotated. When a design with oblique contours is rotated, the contours within the design in fact become horizontal or vertical. However, as we have seen this does not decrease the difficulty of segmentation. This must be due to the fact that the mismatch between the orientation of the contours within the design and the orientation of the imaginary lines of the segmentation still remains. When designs without oblique contours are rotated, the horizontal and vertical contours now become oblique. However, this does not increase task difficulty much. This must be due to the fact that the the imaginary lines to be imposed also have to be in an oblique orientation which matches the orientation of the contours within the rotated design.

This experiment established that the most crucial component of the block design task is that of breaking up the design into four parts (Segmentation). The most important outcome of the experiment is that this is the component on which both the autistic groups were differentiated from their respective control groups. Moreover, it was the component that gave most difficulty to the Lower IQ Non-Autistic group.

The findings that the other components of the block design task investigated here affected the performance of the autistic groups to the same extent as the control groups indicate that the autistic groups have an advantage over the control groups only on one specific component. Thus, one major cognitive component contributing to the 'visuo-spatial' islets of normal and super-normal ability of the autistic subjects can be precisely pinpointed. It is the ability to break up the Whole into its constituent elements. The fact that both the autistic groups demonstrated this ability in this experiment suggests that at least for autistic people with a Performance IQ over 50, this ability is independent of IQ.

The findings of the present experiment , taken together with similar findings on the Children's Embedded Figures Test (Shah & Frith, 1983) suggests that the component of breaking up the Whole as identified here may be reflecting a more general cognitive style of autistic people. Witkin and his colleagues (in Witkin, Lewis, Hertzman, Machover, Meissner and Wapner, 1954; Witkin, Dyk, Faterson, Goodenough and Karp, 1962) have hypothesized that the performance on embedded figures reflects a particular cognitive style, that of field independence - field dependence. Persons who have difficulty breaking up the Whole in order to disembed the simple figure from the complex figure show a field-dependent mode of perceiving in which perception is strongly dominated by the overall organization - they do not readily separate an item from its context (Witkin and Goodenough, 1982). The performance of the autistic subjects suggests that they are relatively field-independent in that they are easily able to break up the given context and are able to perceive constituent items separately from the overiding context. On some tasks such as the block design and the embedded figures such a cognitive style aids performance. However, on tasks where the context needs to be taken into account for effective performance, the cognitive style shown by the autistic subjects would have a detrimental effect on performance.

7.6 Conclusions

The most crucial component of the block design task is that of segmenting the design mentally into four components. This is the only component on which both the autistic groups perform better than their normal control groups. Autistic subjects are able to break up the whole or gestalt easily and thus experimental segmentation does not make much difference to their performance. The control groups, on the other hand, find the whole more difficult to break up mentally, and thus are greatly helped by the physical segmentation which is provided experimentally. The ability to break up the whole (segmentation) is an important cognitive factor contributing to the visuo-spatial islets of abilities in autism.

The factors of Oblique and Rotation affect the performance of the autistic groups as much as the normal control groups. For all these groups, the effects of all three factors of Whole, Oblique and Rotation are strongly inter-related. In particular, the Oblique factor affects the performance on Whole designs but not on Segmented designs. The Rotation of the designs affects the performance if the designs are whole and include oblique contours.

The Lower Non-IQ Autistic group finds the block design task particularly difficult. The major cause of this difficulty is segmentation, i.e. breaking up the design into the four components. For this group, the effects of the three factors are not strongly inter-related, although all three affect performance independently.

7.7. Summary of Chapter (7)

In this chapter, the block design test paradigm was used to investigate the effects of specific cognitive components of visuo-spatial tasks. In particular, three components of the block design task were identified and investigated. These were a) the ability to break up the whole; b) the ability to construct oblique contours within the designs; and c) the ability to construct designs rotated by 90 degrees. The experiment was designed so that the effects of each factor on its own, and in relation with one another could be investigated.

The performance of each autistic group was compared with that of their respective normal control group. The performance of the Lower IQ Non-Autistic group was analyzed separately as the task difficulty of this group was of a different magnitude compared to the other groups.

The results indicated that the autistic groups were significantly less affected by the Whole than the other groups. This was the only factor that distinguished the performance of both the autistic groups from the other groups. All the control groups had particular difficulty in breaking up the whole design into the four components. The Oblique and Rotation factors affected the performance of the autistic groups in the same way and to the same extent as that of their normal control groups. For all these groups, the effects of the Whole, Oblique and Rotation were significantly inter-related. For the Lower IQ Autistic group, all three factors affected the performance independently with the Whole having the strongest effect.

Superior segmentation ability of the autistic groups was discussed in relation to previous similar findings, and it was concluded that this was a major contributory factor towards their visuo-spatial islets of abilities.

CHAPTER EIGHT

Overall Discussion and Conclusions

The overall aim of this thesishas been to investigate how autistic people achieve peaks of performance on so called visuo-spatial tasks. The question throughout has been whether these peaks are achieved by means of abnormal cognitive strategies or whether they reflect intact cognitive processes. The studies were designed in such a way that the performance of the autistic subjects on selected components of visuo-spatial tasks could be isolated and compared with that of control groups on qualitative and quantitative dimensions. These processes were investigated for two groups of autistic subjects of different IQ levels in order to assess their specificity to autism and dependence on general levels of functioning. In this discussion, we first focus on the major findings regarding islets of abilities as they apply to each group, and then go on to discuss the differences between the groups and their implications.

The profile analysis of the IQ-test data confirmed the presence of islets of normal or super-normal abilities on the two tests of visuo-spatial skills, the block design and the object assembly tests, in all the autistic subjects. On the basis of the review of the literature on IQ-test performance of autistic people and the present findings , it can be concluded that autistic people with a non-verbal IQ of at least 50 typically do show these islets of abilities. Their ability level on these is at least in the normal range for their age and thus these peaks are not merely "patches of behaviour where the general retardation is a little less severe" as stated by Prior (1979). These islets of abilities constitute major phenomena of autism , but have all too long been disregarded. In this thesis, an attempt has been made to explore and explain these peculiar phenomena. The findings of all the experiments in the thesis taken together suggest some preliminary answers to the question of how visuo-spatial peaks of performance are achieved by autistic people.

8.1. Segmentation

The results of Experiment (4) using the block design test paradigm indicated that the single most important factor relates to the ability to resist the tendency to be 'drawn' by the coherent whole and instead focus on the constituent elements making up the whole. This is referred to 'segmentation' ability in the present context. The experiment demonstrated that segmentation ability is of utmost importance to the effective performance of the block design task. It is the component which presented most difficulty to a mildly mentally handicapped group who score poorly on the block design test, and the component on which both the autistic groups showed an advantage compared to their normal control groups. It is not that normal people do not have this ability, but autistic people seem to be able to use the skill of segmentation more easily. In this sense, it is abnormal, i.e. out of keeping with expectation from normal development.

The present findings corroborate previous findings of superior segmentation ability shown by autistic children on a different visuo-spatial task, the Children's Embedded Figures

Test (Shah & Frith, 1983). Thus, the segmentation ability on which the autistic groups show superiority is not specific to the block design task and may be a powerful explanatory factor in the autistic person's so called 'islets of abilities'.

The results of Experiment (1) which investigated memory for spatial position did not reveal a special advantage for the autistic subjects. Here, segmentation ability was not tested, but instead the ability to disregard general background cues in visuo-spatial tasks. This experiment demonstrated that autistic subjects did not disregard a super-imposed background of grids or rectangles on a page when they had to remember the exact position of a cross. The 'helpful' and 'interfering' backgrounds were found to affect the performance of both the autistic groups in the same way as that of normal subjects. This experiment is also important in that it confirms the presence of a good (though not superior) memory for spatial position in autistic subjects.

These results taken together with the results of the block design experiment and the results on the Children's Embedded Figures Test (CEFT) enable us to be very specific about the segmentation ability. Autistic subjects show an advantage only when the task requires segmentation of the context or background which is a coherent whole held together by either meaning (as in the CEFT) or a strong visual gestalt (as in the block design task). They do not show an advantage when the context or background is neither of these, for example, a grid pattern.

8.2. Visualization

Experiments (2) and (3) using the mental rotation tasks indicated that both groups of autistic subjects have intact visualization ability. Both groups used the same strategy of mental rotation of an internal representation on these tasks as the control subjects. Most visuo-spatial tasks, including the block design, the object assembly tasks, and jigsaw puzzles require some degree of visualization skill for effective performance. On such visuo-constructional tasks, it is an advantage to be able to imagine how individual components/shapes will appear when rotated. The perfectly intact visualization ability of the autistic subjects indicates that it is another factor that contributes to their excellent performance on visuo-spatial tasks.

The Average IQ Autistic group was able to mentally rotate alpha-numerics significantly faster than the Older Normal control group. Thus, their performance reflected not only intact visualization ability but a superior processing capacity. It is difficult to explain why they showed superior performance on the alpha-numeric stimuli but not on shape stimuli. It is possible that the quality of their stored representation (LTM) of the alpha-numeric symbol is superior and is therefore accessed and manipulated much faster. All groups rotated alpha-numeric stimuli faster than shapes. However, the Average Autistic group benefitted the most. This pattern of performance was also evident in the spatial position experiment. On the condition where the helpful background of small squares was present at the input and output stage, all groups showed an improvement in accuracy. Again, the Average IQ Autistic group showed the most improvement and performed at an optimum level. These results, taken together, suggest that whenever a task became easier for all groups, the Average IQ Autistic groups seemed to be able to take even greater advantage and was able to process spatial information at tremendous speed and was able to maintain absolute accuracy. They lost this advantage as tasks became more difficult. This may partly explain why they are able to score at super-normal levels on visuo-spatial tasks rather than at just normal levels.

8.3 Group differences

Besides the similarities, the investigations also revealed important differences between the two autistic groups. First, there were the clear-cut differences in the severity of the autistic behaviours before age 5, the rate of improvement in these and the manifestation of the social impairment after the age of 16. Next, there were the differences on the IQ-test profiles and the levels of performance on the two critical tests. Finally, the results of the experiments indicated differences in quantitative levels achieved on various component skills of the visuo-spatial tasks. In order to summarize and understand these differences, let us consider the overall picture that emerges for each autistic group separately.

First, the Average IQ Autistic group. The mean overall IQ of this group was near normal (80), the Performance IQ was in the normal range (96) and the Verbal IQ was at the upper end of the mildly retarded range (69). Thus, in terms of intellectual function, for an autistic sample, this group was a very able group. This group showed the core autistic behaviours in a more severe form before age 5. They then showed marked improvement in these behaviours very soon after the age of 5. As adults, they retained all the main features of autism, but in a much milder form than shown in childhood. In particular, there was a tremendous improvement in social behaviour : they showed a severe form of aloofness and indifference to social contact before age 5, but as adults they accepted social contact made by others and were able to interact with people albeit in a stilted mechanical manner. On the Wechsler IQ test, this group showed a very specific deficit on the comprehension subtest and performed in the superior-normal range on the block design and the object assembly subtests. These peaks were referred to as super-normal islets of abilities. On the experiments, their performance on allthe specific components of visuo-spatial tasks that were tested was qualitatively similar to that of a very stringently matched control group of normal subjects. However, on various components, their level of performance in terms of accuracy and reaction time was superior to that of the normal subjects. Thus, although they used the same cognitive strategies as normal subjects and as the Lower IQ Autistic group in solving visuo-spatial problems, they were able to use these strategies faster and more efficiently. This suggests that, besides all the factors identified as contributing to peaks of performance on visuo-spatial tasks in all autistic people, this autistic sub-group has an additional advantage. On the basis of the present findings we cannot be more precise about this additional factor except that it is related to the speed and accuracy of processing visuo-spatial information.

Next, let us consider the Lower IQ Autistic group. The mean Overall IQ of this group was in the mildly retarded range (62), the Performance IQ was in the borderline-normal range (72) and the Verbal IQ was in the lower end of the mildly retarded range (56). Thus, in terms of general intellectual function, this group was less able than the Average IQ Autistic group but still fairly able compared to the majority of the autistic population. This group showed a less severe autistic picture before the age of 5, improved more gradually over the years, and the majority did not reach the level of social behaviour referred to as 'normal but stilted'. Their social interaction pattern was more likely to be of a passive kind. On the Wechsler scales, this group showed global deficits on the verbal subtests and showed normal levels of functioning on the block design and the object assembly subtests. On the various experiments, their performance was qualitatively and quantitatively similar to the performance of the the Younger Normal control group. Thus, they used the same cognitive strategies as normal subjects and the Average IQ Autistic group. The level of performance of this group did not exceed that of the Normal control group except on the segmentation component of the block design task.

Having spelt out the differences between the groups, the question is how can these differences be explained and what are their implications?

Thelevel of intellectual functioning is probably an important explanatory factor for some of the differences. For the Average IQ Autistic group, the early improvement in all autistic features and their better prognosis in social functioning are probably due to their higher IQ levels. They show a reduction in the severity of overt autistic behaviour probably because they have the intelligence to 'rote' learn more acceptable social and language behaviour. The fact that they score very poorly on the comprehension test compared to the other verbal subtests suggests that subtle difficulties in language and comprehension still persist. Hermelin (1983) has suggested that intelligent autistic children may learn appropriate language and social behaviours in a different way from normal children in whom there is an innate system that generates social behaviour. When this system is missing, as in the case of autism, appropriate behaviour can be learned in indivisible chunks. This requires a certain amount of intelligence. This may explain why only the Average IQ group in the present study showed the 'normal but stilted' pattern of social behaviour. The behaviour is presumably stilted because it is a learned repertoire rather thanbeing spontaneous. The relationship between IQ level and social behaviour in autism has been discussed more fully elsewhere (Shah and Wing, 1986).

What the level of IQ cannot explain is the relationship between a more severe form of autism before age 5, super-normal islets of abilities on visuo-spatial tasks, and a tendency to perform more accurately and faster on various components of visuo-spatial skills. The present findings do not provide any conclusive answers to this puzzling and complex association but are able to rule out certain explanations, and offer tentative suggestions about possible links between the factors.

The Average IQ Autistic group used the same strategies for processing visuo-spatial information as the Lower IQ Autistic group. There is one peculiarity of function which relates to the high level of visuo-spatial skill and the autistic syndrome. This is the high level of segmentation ability which is common to both autistic groups. Another factor related to the high level of visuo-spatial skill isaccuracy and rate of processing spatial information. On this only the Average IQ Autistic group excels normal levels. These findings suggest that super-normal peaks on visuo-spatial tasks as shown by the Average IQ Autistic group are due to the presence of both these factors: a) segmentation, which is an autism-specific factor and independent of general intelligence; and b) high processing ability which is related to a normal level of non-verbal intelligence. Segmentation alone is not sufficient for visuo-spatial performance to reach super-normal levels. This was demonstrated by the Lower IQ Autistic who had good segmentation skill but below normal non-verbal IQ. The Lower IQ Non-Autistic group has a disadvantage on both the factors: they are poor at segmentation and do not have a high level of processing capacity or normal non-verbal IQ. Thus, their performance on visuo-spatial tasks is at a very low level compared with the other groups. Both the normal groups are weaker on segmentation ability than the autistic groups, but they, nevertheless, have normal intelligence and hence at least a normal rate of processing spatial information. Thus, they have part of the requirements for high visuo-spatial ability, leading to normal, rather than super-normal, levels of performance on specific visuo-spatial tasks. These findings apply to autistic subjects with IQ of 50 and above. Those below this level are mostly unable to perform on the block design or embedded figures type of tasks. It is possible that if a suitable task requiring segmentation ability could be given to autistic subjects of IQ below 50, they may show a higher segmentation ability than their other skills. However, their severe general retardation, and hence poor information processing ability would result in a low level of performance.

The question that remains is why does the autistic group of normal intelligence and super-normal ability on visuo-spatial tasks show the most severe autistic symptoms in early childhood?

One possibility is that this association is due to a referral artefact. It is possible that autistic children with super-normal islets of ability are able to use compensatory learning strategies based on their high level of information processing efficiency, and thus do not get referred unless their autistic behaviour is very severe. On the other hand, autistic children who are less intelligent and do not have the high information processing capacity would not be able to compensate for their learning difficulties, and hence even mild autistic behaviour would be noticeable. This explanation suggests that the severity of autistic behaviour in childhood may be independent of the overall ability level.

If we assume that the association is real and not due to any referral bias, we need to look for causal explanations.

It is conceivable that the two factors which are assets on visuo-spatial tasks somehow represent a disadvantage in processing information relevant to social interaction. High segmentation ability, i.e. the tendency to disregard meaning represented by the whole would be a disadvantage in social situations where appropriate and effective interaction depends on the personal and social context. More research specifically aimed at investigating this question is required before drawing any conclusions. Frith (forthcoming) speculates that the basic underlying cognitive deficit in autism is a tendency towards 'detachment' in a very general sense. This detachment is hypothesized to originate from a failure of a "drive to coherence" in central information processing mechanisms. Frith has discussed how such detachment would in fact lead to good segmentation ability and to poor communication ability at the same time. By proposing a common underlying cognitive deficit which would affect the processing of all kinds of information, this theory is able to link superior segmentation ability and social impairment in autism. However, this theory is not able to explain the association between the severity of the social impairment before age 5 and the normal level of intelligence and super-normal islets of ability.

On the basis of the present evidence, it is not possible to be more specific about this association or to propose any causal explanations. Further research is needed to look more closely at information processing in social situations and in islets of abilities.

8.4. Limitations of the present study

This study investigated only a few components of two-dimensional visuo-spatial tasks. In order to fully understand the nature of this islet of ability in sub-groups of autistic people, more research is needed a) to look at other components of spatial tasks; b) to investigate segmentation ability in a variety of tasks; and c) to investigate the performance of autistic people on pure spatial tasks such as map-reading, spatial orientation in the environment, judgement of left-right orientation, etc.

Another limitation of the present study relates to the small numbers in the two autistic groups. It is hard to obtain large numbers of subjects of the right age and ability levels in local centres for autistic people. It was felt that the advantage of having homogeneous subgroups outweighed the disadvantage of having small numbers in each group.

8.5. Implications of the findings

The findings of this series of investigations has various implications.

First, clincial and quantitative differences in subgroups of autistic subjects of different levels of IQ have implications for the selection of autistic and control subjects in research studies of autism. The autistic group should be kept as homogeneous as possible with regard to IQ level. Otherwise, the results could be inaccurate and misleading especially if the autistic group is compared to a group-matched control group. In the present investigations, if the autistic groups had been combined as one and compared with one control group matched on the mean IQ of the total autistic group, spurious differences would have been found between the autistic and control groups. This point is all the more important in studies investigating the deficits of autistic subjects.

The marked subtest scatter in IQ-test profiles of autistic subjects shows that the overall Full-scale IQ , the Performance IQ or the Verbal IQ cannot be taken as reflecting the same level of skills on individual subtests as that of control groups of comparable overall IQ levels. This raises the question of the meaningfulness of matching autistic subjects on the basis of overall IQ whether this is Full-scale, Performance or Verbal. There are no easy solutions to this problem. However, if research studies are to provide real rather than artefactual answers, researchers should pay more attention to matching procedures. One possible solution would be to match on the level of relevant subtest performance , or to use multiple control groups.

Second, the findings regarding intact and superior functioning shown by autistic subjects on spatial tasks may have implications for teaching and training. It may be possible to train autistic people to use spatial strategies for a wider range of tasks. More research along these lines is needed.

Third, the level of performance reached by both the autistic groups on the block design task brings into question the validity of the global concept of brain-damage. Previous studies (described in Chapter 7) have unanimously reported the tendency for brain-damaged patients to perform particularly poorly on the block design task. Yet, it is on this task precisely that autistic people, in whom organic brain dysfunction has been implicated, perform particularly well. It would be interesting to investigate visuo-spatial islets of abilities in groups of autistic people with identifiable conditions associated with known brain damage. In addition, a potentially valuable (though very expensive) research project might be to obtain PET scans of subjects while they were engaged in the block design and other spatial tasks. This might indicate which part(s) of the brain are being involved in these tasks the different subgroups.

Finally, the findings have implications for sub-classification of autistic subjects. This could be based along various dimensions: a) on the level non-verbal intelligence; b) on the level of visuo-spatial islets of abilities; c) on the severity of autistic behaviour in childhood; and d) on the manifestation of social impairment in adults. Such systems of sub-classification may aid diagnosis, and would certainly be useful in research studies. In addition , in view of the suggestions from epidemiological research (e.g. Wing & Gould, 1979), that typical autism represents only one subgroup of a wider spectrum of conditions characterized by social impairment - the so called Pervasive Developmental Disorders (AAP, 1987), it would be of theoretical and practical use to investigate visuo-spatial skills of subjects within this range, but not fitting the criteria for classic autism.

8.6. Conclusions

Autistic subjects with a Performance IQ between 50 and 85 demonstrate islets of <u>normal</u> abilities on visuo-spatial tasks. Autistic subjects with Performance IQ between 85 and 115 perform at a <u>super-normal</u> level on these islets.

These peaks of performance are achieved by one abnormal cognitive strategy of segmentation, and intact levels of functioning on various specifically spatial components of visuo-spatial tasks. These factors are sufficient in themselves to explain the normal levels of performance as shown by the Lower IQ Autistic group. However, additional factors are responsible for the super-normal levels of performance reached by the Average IQ Autistic group. These are a higher level of general processing efficiency and specific factors related to the speed and accuracy of processing visuo-spatial information.

There are important differences between the two autistic groups on clinical factors and quantitative aspects of performance. There is a striking association between the severity of autistic behaviour in early childhood, super-normal level of visuo-spatial skills, normal non-verbal IQ and a high level of speed and accuracy on some components of visuo-spatial tasks. This association may be an artefact of referral bias or may have causal links which are as yet unknown.

REFERENCES

ALEXANDER,W.P.(1932). A new performance test of intelligence. British Journal of Psychology, 23, 52-63.

ALPERN,G. D.(1967). Measurement of "untestable" autistic children. Journal of Abnormal Psychology, 72, 478-486.

AMERICAN PSYCHIATRIC ASSOCIATION (1987). Diagnostic and Statistical Manual of Mental Disorders. Third Edition - Revised. Washington DC: American Psychiatric Association

AMES, L. B., LEAMER, J., METRAUX, R., & WALKER, R. (1953). Development of perception in the young child as observed in response to the Rorschach Test Blots. The Journal of Genetic Psychology, 82, 183-204.

ANASTASI, A. & LEVEE, R. (1960). Intellectual defect and musical talent: a case report. American Journal of Mental Deficiency, 64, 695-703.

ANDERSON, J. R. (1978). Arguments concerning representations for mental imagery. Psychological Review, 85, 249-277.

APPLEBAUM, E., EGEL, A., KOEGAL, R. & IMHOFF, B. (1979). Measuring musical abilities of autistic children. Journal of Autism and Developmental Disorders, 9, 279-286.

ASARNOW, R. F., TANGUAY, P. E., BOTT, L. & FREEMAN, B. J. (1987). Patterns of intellectual functioning in non-retarded autistic and schizophrenic children. Journal of Child Psychology & Psychiatry, 28, 273-280.

BARON-COHEN, S. (1987). Autism and symbolic play. British Journal of Developmental Psychology, 5, 139-148.

BARON-COHEN, S., LESLIE, A. M. & FRITH, U. (1986). Mechanical, behavioural and intentional understanding of picture stories in autistic children. British Journal of Developmental Psychology , 4, 113-125.

BARTAK, L. & RUTTER, M. (1976). Differences between mentally retarded and normally intelligent autistic children. Journal of Autism and Childhood Schizophrenia, 6 (2), 109-120.

BARTAK, L., RUTTER, M. & COX, A. (1975). A comparative study of infantile autism and specific developmental receptive language disorders: I. The children. British Journal Of Psychiatry, 126, 127-145.

BENDER, L., & GRUGETT, A. (1956). A study of certain epidemiological factors in a group of children with childhood schizophrenia. American Journal of Orthopsychiatry, 26, 131-1

BENTON, A. L. (1938). The performance of pre-school children on the Kohs Block Design Test. Journal of Genetic Psychology, 53, 213-233.

BERG, C., HERTZOG, C. & HUNT, E. (1982). Age differences in the speed of mental rotation. Developmental Psychology, 18 (1), 95-107.

BINET, A. (1894). Psychologie des grandes calculateurs (et de joueurs d'echecs). Paris: Hachette.

BOLLES, M. & GODSTEIN, K. (1938). A study of impairment of 'abstract behaviour' in schizophrenic patients. Psychiatric Quarterly, 12, 42-65.

BREMNER, J. G. (1982). Object localization in infancy. In M. Potegal (Ed.), Spatial Abilities: Development and Physiological Foundations. New York: Academic Press.

BREMNER, J.G. & BRYANT, P. E. (1977). Place versus response as the basis of spatial errors made by young infants. Journal of Experimental Child Psychology, 23, 162-171.

BRYANT, P. E. (1969). Perception and memory of the orientation of visually presented lines by children. Nature, 224, 1331-1332.

BRYANT, P. (1974). Perception and Understanding in Young Children. London: Methuen & Co. Ltd.

BURNS, B. D., MANDEL, G., PRITCHARD, R., & WEBB, C. (1969). The perception of briefly exposed point sources of light. Quarterly Journal of Experimental Psychology, 21, 299-311.

BUTTERWORTH, G. (1975). Object identity in infancy: The interaction of spatial location codes in determining search errors. Child Development, 46, 866-870.

BYRD, H. (1920). A case of phenomenal memorising in a feeble minded negro. Journal of Applied Psychology, 4, 202-206.

CAIN, A. (1969). Special "isolated" abilities in severely psychotic young children. Psychiatry: Journal for the Study of Interpersonal Processes, 32 (2), 137-149.

CASSEL, R. H. (1957). Differentiation between the mental defective with psychosis and the childhood schizophrenic functioning as a mental defective. American Journal of Mental Deficiency, 62, 103-107.

CERELLA, J., POON, L. W. & FOZARD, J. L. (1981). Mental rotation and age reconsidered. Journal of Gerontology, 36, 620-624.

CLARKE, A. D. B. & CLARKE, A. M. (1973). What are the Problems? An evaluation of recent research relating to theory and practice. In A. D. B. Clarke & A. M. Clarke (Eds). Mental Retardation and Behavioural Research. Study Group No. 4. Edinburgh and London: Churchill Livingstone.

COBRINIK, L.(1959). The performance of brain-injured children on hidden-figure tasks. American Journal of Psychology, 72, 566-571.

COBRINIK, L. (1974). Unusual reading ability in severely disturbed children: Clinical observation and retrospective inquiry. Journal of Autism & childhood Schizophrenia, 4 (2), 163-175.

COHEN, J. (1959). The factorial structure of the WISC at ages 7-6, 10-16 and 13-6. Journal of Consulting Psychology, 23, 285-299.

COLBERT, E.G. & KOEGLER, R. (1958). Diagnosis of schizophrenia in young children. California Medicine, 89, 215-216.

COOPER, L. A. (1975). Mental transformation of random two-dimensional shapes. Cognitive Psychology, 7, 20-43.

COOPER, L. A. (1976). Demonstration of a mental analog of an external rotation. Perception & Psychophysics, 19, 296-304.

COOPER, L. A. & PODGORNY, P. (1976). Mental transformations and visual comparison processes: Effects of complexity and similarity. Journal of Experimental Psychology: Human Perception and Performance, 2, 503-514.

COOPER, L. A. & SHEPARD, R. N. (1973)a. The time required to prepare for a rotated stimulus. Memory & Cognition, 1, 246-250.

COOPER, L. A. & SHEPARD, R. N. (1973)b. Chronometric studies of the rotation of mental images. In W. G. Chase (Ed.): Visual Information Processing. New York: Academic Press.

CORBALLIS, M. C. & ROLDAN, C. E. (1975). Detection of symmetry as a function of angular orientation. Journal of Experimental Psychology: Human Perception and Performance, 1, 221-230.

CRAMAUSSEL, E. (1924). Ce que voient des yeux d'enfants. Journal of Psychology, 21, 161-170.

DEMYER, M., BARTON, S. & NORTON, J. A. (1972). A comparison of adaptive, verbal and motor profiles of psychotic and non-psychotic subnormal children. Journal of Autism and Childhood Schizophrenia, 2, 359-377.

DEMYER, M. K., BARTON, S., DEMYER, W. E., NORTON, J. A., ALLEN, S. & STEELE, R. (1973). Prognosis in autism: A follow-up study. Journal of Autism and Childhood Schizophrenia, 3, 199-246.

DEMYER, M., BARTON, S., ALPERN, G., KIMBERLIN, C., ALLEN, J., YANG, E. & STEELE, R. (1974). The measured intelligence of autistic children. Journal of Autism and Childhood Schizophrenia, 4 (1), 42-60.

DEMYER, M., NORTON, J. & BARTON, S. (1971). Social and adaptive behaviors of autistic children as measured in a structured psychiatric interview. In D. W. Churchill, G. D. Alpern, & M.K. Demyer (eds.). Infantile Autism: Proceedings of Indiana University Colloquium. Springfield, III: Charles C. Thomas.

DE RENZI, E. & SPINNLER, H. (1966). Visual recognition in patients with unilateral cerebral disease. Journal of Nervous Mental Disorders, 142, 515-525.

EIGLER, P. (1930). The Kohs Block Design Test. Child Development, 1, 341-342.

ELLIOT, C. D., MURRAY, D. J., & PEARSON, L. S. (1978). Manual for the British Ability Scales. Windsor: NFER Publishing Co. Ltd.

FREEMAN, B., RITVO, E., SCROTH, P., TONICK, I., GUTHRIE, D. & WAKE, L. (1981). Behavioral Characteristics of High- and Low-IQ Autistic Children. American Journal of Psychiatry, 138 (1), 25-29.

FRITH, U. (1970). Studies in pattern detection in normal and autistic children. II: Reproduction and production of color sequences. Experimental Child Psychology, 10 (1), 120-135.

FRITH, U. (1972). Cognitive mechanisms in autism: Experiments with color and tone sequence production. Journal of Autism and Childhood Schizophrenia, 2 (2), 160-173.

FRITH, U. (1984). A new perspective in research on autism. Paper presented at the Group de travail sur les aspects cognitifs de l'autism. Paris. September 1984.

FRITH, U. (forthcoming). Autism: The Lonely Mind. Oxford: Blackwell

FRITH, U. & HERMELIN, B. (1969). The role of visual and motor cues for normal, subnormal and autistic children. Journal of Child Psychology and Psychiatry, 10, 153-163.

FRITH, U. & SNOWLING, M. (1983). Reading for meaning and reading for sound in autistic and dyslexic children. British Journal of Developmental Psychology, 1, 329-342.

GALLAGHER, J. J. (1962). Personality development in pre-adoloscent, mentally retarded children. American Journal of Mental Deficiency, 67, 296-301.

GARDNER, H. (1983). Frames of Mind. London: Heinemann.

GAYLORD, S. A., & MARSH, G. R. (1975). Age differences in the speed of a spatial cognitive process. Journal of Gerontology, 30, 674-678.

GHENT, L. (1956). Perception of overlapping and embedded figures by children of different ages. American Journal of Psychology, 69, 575-587.

GILLIES, S. M. (1965). Some abilities of psychotic children and subnormal controls. Journal of Mental Deficiency Research, 9 (2), 89-101.

GOLDFARB, W. (1956). Receptor preferences in schizophrenic children. Archives of Neurology and Psychiatry, 76, 643-652.

GOLDSTEIN, K. & SCHEERER, M. (1941). Abstract and concrete behaviour - An experimental study with special tests. Psychological Monographs, 53 (2), Whole No. 239, 1-149.

GOODMAN, V. (1972). A case study of an "autistic savant": Mental function in the psychotic child with markedly discrepant abilities. Journal of Child Psychology and Psychiatry, 13, 267-278.

GOULD, J. (1986). The Lowe and Costello Symbolic Play Test in socially-impaired children. Journal of Autism and Developmental Disorders, 16, 199-213.

GRANDIN, T. (1984). My experiences as an autistic child and review of selected literature. Journal of Orthomolecular Psychiatry, 13 (3), 144-174.

GRATCH, G. (1975). Recent studies based on Piaget's view of object concept development. In L. B. Cohen & P. Salapatek (Eds.) Infant Perception: From Sensation to Cognition (Vol. 2). New York: Academic Press.

HAMMES, J. G. W. & LANGDELL, T. (1981). Precursors of symbolic formation and childhood autism. Journal of Autism and Developmental Disorders, 11, 331-346.

HAND, D. J. & TAYLOR, C. C. (1987). Multivariate Analysis of Variance and Repeated Measures. London: Chapman & Hall.

HASLAM, J. (1809). Observations on Madness and Melancholy, pp. 185-206. London: Haydon.

HEMMENDINGER, L. (1953). Perceptual organization and development as reflected in the structure of Rorschach test responses. Journal of Projective Techniques, 17, 162-170.

HERMELIN, B. (1978). Images and Language. In M. Rutter & E. Schopler (Eds.). A Reappraisal of Concepts and Treatment. New York and London: Plenum Press.

HERMELIN, B. (1983). Thoughts and feelings. Australian Autism Review, 1, 10-19.

HERMELIN, B. & FRITH, U. (1971). Psychological studies of childhood autism. Can autistic children make sense of what they see and hear? Journal of Special Education, 5, 1107-1117.

HERMELIN, B. & O'CONNOR, N. (1970). Psychological Experiments with Autistic Children. Oxford: Pergamon Press.

HERMELIN, B. & O'CONNOR, N. (1986). Idiot-savant calendrical calculators: rules and regularities. Psychological Medicine, 16, 885-893.

HILL, A. L. (1977). Idiot savants: rate of incidence. Perceptual and Motor Skills, 44 (1), 161-162.

HILL, A. L. (1978). Savant mentally retarded individuals with special skills. In N. R. Ellis. (Ed.) International Review of Research in Mental Retardation, Vol. 9, 277-298. New York: Academic Press.

HOBSON, R. P. (1984). Early childhood autism and the question of egocentrism. Journal of Autism and Developmental Disorders, 14, 85-106.

HOLMES, N., SHAH, A. & WING, L. (1982). The Disability Assessment Schedule: a brief screening device for use with the mentally retarded. Psychological Medicine, 12, 879-890.

HOWLIN, P. (1986). An Overview of Social Behaviour in Autism. In E. Schopler & G. B. Mesibov (Eds.). Social Behaviour in Autism. New York and London: Plenum Press.

HUTTENLOCHER, J. (1967). Discrimination of figure orientation: effects of relative position. Journal of Comparative and Physiological Psychology, 63, 359-361.

ITARD, J. M. G. (1801). Of the First Development of the Young Savage of Aveyron. Reprinted in Wolf Children and the Wild Boy of Aveyron. Matson, L. & Itard, J. M. G. (1972), pp 95-140. London: NLB

ITARD, J. M. G. (1807). Report on the Progress of Victor of Aveyron. Reprinted in Wolf Children and the Wild Boy of Aveyron. Malson, L. & Itard, J. M. G. (1972), pp 141-179.

JENSEN, A. R. (1979). The nature of intelligence and its relation to learning. Journal of Research and Development in Education, 12, 79-95.

KAIL, R., PELLEGRINO, J., & CARTER, P. (1980). Developmental changes in mental rotation. Journal of Experimental Child Psychology, 29, 102-116.

KANNER, L. (1943). Autistic disturbances of affective contact, Nervous Child, 2, 217-250.

KANNER, L. (1952). Emotional interference with intellectual functioning. American Journal of Mental Deficiency, 56, 701-707.

KANNER, L. (1971). Follow-up study of eleven autistic children originally reported in 1943. Journal of Autism and Childhood Schizophrenia, 1, 119-145.

KANNER, L. & EISENBERG, L. (1955). Notes on the follow-up studies of autistic children. In P. H. Hoch & J. Zubin (Eds.). Psychopathology of Childhood. New York: Grune & Stratton, Inc.

KANNER, L. & EISENBERG, L. (1956). Early infantile autism 1943-1955. American Journal of Orthopsychiatry, 26, 55-65.

KOFFKA, K. (1935). Principles of Gestalt Psychology. New York: Harcourt.

KOHS, S. C. (1923). Intelligence Measurement. New York: Macmillan.

LIEBOWITZ, H. W., MYERS, N. A. & GRANT, D. (1955). Radial localization of a single stimulus as a function of luminance and duration of exposure. Journal of the Optical Society of America, 45, 76-78.

LOCKYER, L. (1967). A psychological follow-up study of psychotic children. Unpublished Ph.D Thesis. University of London.

LOCKYER, L. & RUTTER, M. (1969). A five- to fifteen-year follow-up study of infantile psychosis - III. Psychological aspects. The British Journal of Psychiatry, 115, 865-882.

LOCKYER, L. & RUTTER, M. (1970). A five- to fifteen-year follow-up study of infantile psychosis - IV. Patterns of cognitive ability. British Journal of Social and Clinical Psychology, 9, 152-163.

LOTTER, V. (1966). Epidemiology of autistic conditions in young children: prevalence. Social Psychiatry, 1, 124-147.

LOTTER, V. (1974)a. Social adjustment and placement of autistic children in Middlesex: A follow-up study. Journal of Autism and Childhood Schizophrenia, 4, 11-32.

LOTTER, V. (1974)b. Factors related to outcome in autistic children. Journal of Autism and Childhood Schizophrenia, 4, 263-277.

MACCOBY, E. & JACKLIN, C. (1975). The Psychology of sex differences. London: Oxford University Press.

MCFIE, J. & PIERCY, M. F. (1952). Intellectual impairment with localized cerebral lesions. Brain, 75, 292-311.

MACH, E. (1959). The analysis of sensation (C. M. Williams, trans.). New York: Dover. Originally published, 1886.

MARMOR, G. S. (1975). Mental rotation and number conservation: Are they related? Developmental Psychology. 13 (4), 320-325.

MAXWELL, A. E. (1959). A factorial analysis of the Wechsler Intelligence Scale for Children. British Journal of Educational Psychology, 29, 237-241.

MEILI-DWORETZKI, G. (1956). The development of perception in the Rorschach. In B. Klopfer (Ed.). Developments in the Rorschach Technique. World Book, 108-176.

METZLER, J. (1973). Cognitive analogues of the rotation of three dimensional objects. Unpublished doctoral dissertation. Stanford University.

METZLER, J. & SHEPARD, R. N. (1974). Transformational studies of the internal representation of three-dimensional objects. In R. Solso (Ed.). Theories in cognitive psychology: The Loyola symposium. Hillsdale, N.J: Lawrence Erlbaum Associates.

MITTLER, P. GILLIES, S. & JUKES, E. (1966). Prognosis in psychotic children: report of a follow-up study. Journal of Mental Deficiency Research, 10, 73-83.

MOGRIDGE, G. & HEALY, W. A. (1912). A feeble-minded genius. Journal of Psycho-Astenics, 16, 93-102.

NADEL, A. B. (1938). A qualitative analysis of behaviour following cerebral lesions diagnosed as primarily affecting the frontal lobes. Archives of Psychology, Serial No. 224.

NEWSON, E., DAWSON, M. & EVERARD, P. (1982). The natural history of able autistic people: Their management and functioning in social context. (Unpublished Report for the DHSS). Child Development Research Unit, The University of Nottingham.

NURCOMBE, B. & PARKER, N. (1964). The idiot savant. Journal of American Child Psychiatry. 3, 469-487.

O'CONNOR, N. & HERMELIN, B. (1975). Modality specific spatial coordinates. Perception and Psychophysics, 17, 213-216.

O'CONNOR, N. & HERMELIN, B. (1978). Seeing and Hearing and Space and Time. London: Academic Press.

O'CONNOR, N. & HERMELIN, B. (1984). Idiot savant calendrical calculators: maths or memory? Psychological Medicine, 14, 801-806.

OGILVIE, J. C. & TAYLOR, M. M. (1958). Effect of orientation on the visibility of fine wires. Journal of the Optical Society of America, 48, 628-629.

OHTA, M. (1987). Cognitive disorders of infantile autism: A study employing the WISC, Spatial Relation Conceptualization and Gesture Imitations. Journal of Autism and Development Disorders, 17 (1), 45-62.

OLSON, D.R. (1970). Cognitive development. The child's acquisition of diagonality. New York: Academic Press.

OLSON, D. & HILDYARD, A. (1977). On the mental representation of oblique orientation. Canadian Journal of Psychology, 31, 3-13.

ORNITZ, E. & RITVO, E. (1968). Perceptual inconstancy in early infantile autism. Archives of General Psychiatry, 18, 76-98.

PALMER, S. E. (1975). Visual perception and world of knowledge: Notes on a model of sensory-cognitive interaction. In D. A. Norman & D. E. Rumelhart (Eds.). Explorations in cognition. San Francisco: W. H. Freeman.

PALMER, S. E. (1977). Hierarchical structure in perceptual representation. Cognitve Psychology, 9, 441-474.

PAYNE, R. W. (1965). A review of the Goldstein-Scheerer Test Battery. In O.K. Buros (Ed.). Sixth Mental Measurement Year Book. New Jersey: The Gryphon Press.

PIAGET, J. (1952). The Origins of Intelligence in Children, 2nd ed. New York: University Press.

PIAGET, J. (1954). <u>The Construction of Reality in the Child</u>. New York: Basic Books.

PIZZAMIGLIO, L. & CARLI, R. (1974). Visual, tactile and acoustic embedded figures tests in patients with unilateral brain damage. <u>Cortex</u>, 10 (3), 238-246.

PRIOR, M. R. (1979). Cognitive abilities and disabilites in infantile autism: a review. <u>Journal of Abnormal Child Psychology</u>, 7(4), 357-380.

PYLYSHYN, Z. W. (1973). What the mind's eye tells the mind's brain: A critique of mental imagery. <u>Psychological Bulletin</u>, 80, 1-24.

PYLYSHYN, Z. W. (1979). The rate of "mental rotation" of images: A test of a holistic analogue hypothesis. <u>Memory and Cognition</u>, 7, 19-28.

PYLYSHYN, Z. W. (1981). The imagery debate: Analogue media versus tactic knowledge. <u>Psychological Review</u>, 87, 16-45.

REISSENWEBER, M. (1953). The use of modified block designs in the evaluation and training of the brain-injured. <u>Psychological Monographs: General and applied</u>. Vol 67 (21), Whole No. 371. 1-28.

RIGUET, C. B., TAYLOR, N.D., BENAROYA, S. & KLEIN, L. S. (1981). Symbolic play in autistic, Down's and normal children of equivalent mental age. Journal of Autism and Developmental Disorders, 11, 439-448.

RIMLAND, B. (1964). Infantile Autism. New York: Appleton-Century-Crofts.

RIMLAND, B. (1978). Savant capabilities of autistic children and their cognitive implications. In G. Serban (Ed.). Cognitive defects in the development of mental illness. New York: Brunner Mazel, 43-65.

ROCK, I. (1966). The Nature of Perceptual Adaptation. New York: Basic Books.

ROSEN, A. M. (1981). Adult calculators in a psychiatric OPD: A report of two cases and comparative analysis of abilities. Journal of Autism and Developmental Disorders, 11, 285-292.

ROTHSTEIN, H. S. (1942). A study of aments with special abilities. Unpublished Master's thesis, Columbia University.

RUDEL, R. G. & TEUBER, H. L. (1963). Discrimination of direction of lines in children. Journal of Comparative and Physiological Psychology, 56, 892-898.

RUDEL, R. G. & TEUBER, H. L. (1971). Spatial orientation in normal children and in children with early brain injury. Neuropsychologica, 9, 401-407.

RUTTER, M. (1966). Behavioural and cognitive characteristics of series of psychotic children. In J. Wing (Ed.). Early Childhood Autism: Clinical , Educational and Social Aspects. Oxford: Pergamon Press.

RUTTER, M. (1970). Autistic children: Infancy to adulthood. Seminars in Psychiatry, Vol 2, 435-450.

RUTTER, M. (1984). Infantile autism and other pervasive developmental disorders. In M. Rutter & L. Hersov (Eds.). Child and Adolescent Psychiatry: Modern approaches (2nd Ed.). Oxford: Blackwell Scientific

SATTLER, J. M. (1974). Assessment of Children's Intelligence. Philadelphia: Saunders.

SCHEERER, M., ROTHMAN, E. & GOLDSTEIN, K. (1945). A case of "idiot-savant": an experimental study of personality organization. Psychological Monographs. 58, Whole No. 269.

SEGERS, J. E. (1926). Recherches sur la perception visuelle chez les enfants ages de trois a douze ans et leur application a l'education. Journal de Psychologie, 23, 608.

SELFE, L. (1977). Nadia: A case of extraordinary drawing ability in an autistic child. London: Academic Press.

SELFE, L. (1983). Normal and anomalous representational drawing in children. London: Academic Press.

SHAH, A. (1986). Impairment of social interaction in autism and mental retardation: A 12-year follow-up study. In J. M. Berg (Ed.). Science and Service in Mental Retardation. London: Methuen & Co. Ltd.

SHAH, A. & FRITH, U. (1983). An islet of ability in autistic children: A research note. Journal of Child Psychology and Psychiatry, 24 (4). 613-620.

SHAH, A. & HOLMES, N. (1985). Brief Report: The use of the Leiter International Performance Scale with Autistic Children. Journal of Autism and Developmental Disorders, 15(2), 195-203

SHAH, A. & WING, L. (1986). Cognitive impairments affecting social behaviour in autism. In E. Schopler & G. B. Mesibov (Eds.). Social Behaviour in Autism. New York and London: Plenum Press.

SHAPIRO, M. B. (1951). Experimental studies of a perceptual anomaly: 1, Initial experiments. Journal of Mental Science, 97, 90-100.

SHAPIRO, M. B. (1952). Experimental studies of a perceptual anomaly: 2, Confirmatory and explanatory experiments. Journal of Mental Science, 98, 605-617.

SHAPIRO, M. B. (1954). An experimental investigation of the block design rotation effect: An analysis of a psychological effect of brain damage. British Journal of Medical Psychology , 27, 84-88.

SHEPARD, R. N. (1973). Studies of the form, formation and transformation of internal representations. In F. Galanter (Ed.). Cognitive Mechanisms. Washington D.C: Winston & Sons.

SHEPARD, R. N. & COOPER (1982). Mental images and their transformation. Cambridge, Massachusetts and London: The Mit Press.

SHEPARD, R. N. & METZLER, J. (1971). Mental rotation of three-dimensional objects. Science, 171, 701-703.

SPEARMAN, C. (1927). The Nature of Intelligence and the Principles of Cognition. London: Macmillan.

SPIVACK, G. & LEVINE, M. (1964). The Devereux child behaviour rating scale: A study of symptom behaviors in latency age atypical children. American Journal of Mental Deficiency, 68, 700-717.

TERMAN, L. M. & MERRILL, M. A. (1960). Stanford-Binet Intelligence Scale: Manual for the Third Revision, Form L-M. Boston: Houghton-Miffin.

TEUBER, H. L., BATTERSBY, W. S. & BENDER, M. B. (1951). Performance of complex visual tasks after cerebral lesions. Journal of Nervous and Mental Diseases. 114, 413-429.

TEUBER, H. L. & WEINSTEIN, S. (1956). Ability to discover hidden figures after cerebral lesions. Archives of Neurological Psychiatry, 76, 369-379.

THURSTONE, L. L. (1938). Primary mental abilities. Psychometric Monographs, 1, Chicago: University of Chicago Press.

TSAI, L. & BEISLER, J. M. (1983). The development of sex differences in infantile autism. British Journal of Psychiatry, 142, 373-378.

TOOTH, G. (1947). On the use of mental tests for the measurement of disability after head injury: with a comparison between the results of these tests in patients after head injury and psychoneurotics. Journal of Neurological Neurosurgery and Psychiatry, 10, 1-11.

TYMCHUK, A. J., SIMMONS, J. Q. & NEAFSEY, S. (1977). Intellectual characteristics of adolescent childhood psychotics with high verbal ability. Journal of Mental Deficiency Research, 21, 133-138.

UNGERER, J. A. & SIGMAN, M. (1981). Symbolic play and language comprehension in autistic children. Journal of the American Academy of Child Psychiatry, 20, 318-337.

VIITAMAKI, R. O. (1964). Psychosis in childhood: a psychological follow-up study. Acta Psychiatrica de Scandinavia, 40, Supp. 174, 33-73.

WALTERS, A. (1942). A genetic study of geometrical-optical illusions. Genetic Psychological Monographs, 25, 101.

WARD, T. F. (1963). The course of childhood schizophrenia. Diseases of the Nervous System, 24, 211-220.

WASSING, H. E. (1965). Cognitive functioning in early infantile autism: an examination of four cases by means of the WISC. Acta Paedopsychiatrica 32, 122-135.

WECHSLER, D. (1955). Manual for the Wechsler Adult Intelligence Scale. New York: The Psychological Corporation.

WECHSLER, D. (1974). Manual for the Wechsler Intelligence Scale for Children - Revised. New York: The Psychological Corporation.

WERTHEIMER, R. M. (1923). Untersuchungen zur lehre von der gestalt: II. Psychologishe Forschung, 4, 301-350.

WILTSHIRE, S. (1987). Drawings. London:Dent.

WING, J.K. (1963). Epidemiology of early childhood autism. Developmental Medicine and Child Neurology, 5, 646-647.

WING. L. (1966). The handicaps of autistic children - a comparative study. Journal of Child Psychology and Psychiatry, 10, 1-40.

WING, L. (1971). Perceptual and language development in autistic children: a comparative study. In M. Rutter (Ed.). Infantile Autism: Concepts, Characteristics and Treatment. London: Churchill.

WING, L. (1976). Diagnosis, Clinical Description and Prognosis. In L. Wing (Ed.). Early Childhood Autism: Clinical, Educational and Social Aspects. 2nd Ed. Oxford: Pergamon Press.

WING, L. (1981)a. Language, social and cognitive impairments in autism and severe mental retardation. Journal of Autism and Developmental Disorders, 11, 31-44.

WING, L. (1981)b. Sex ratios in early childhood autism and related conditions. Psychiatry Research, 5, 129-137.

WING, L. & GOULD, J. (1978). Systematic recording of behavior and skills of retarded and psychotic children. Journal of Autism and Childhood Schizophrenia, 8, 79-97.

WING, L. & GOULD, J. (1979). Severe impairments of social interaction and associated abnormalities in children: epidemiology and classification. Journal of Autism and Developmental Disorders, 9, 11-29.

WING, L., GOULD, J., YEATES, J. R. & BRIERLY, L. M. (1977). Symbolic play in severely mentally retarded and in autistic children. Journal of Child Psychology and Psychiatry, 18, 167-178.

WITKIN, A. A. (1950). Individual differences in ease of perception of embedded figures. Journal of Personality, 19, 1-15.

WITKIN, H. A., DYK, R., FATERSON, H. F., GOODENOUGH, D. R. & KARP, S. A. (1962). Psychological differentiation. New York: John Wiley & Sons.

WITKIN, H. A. & GOODENOUGH, D. R. (1981). Cognitive styles: Essence and origins. New York: International University Press.

WITKIN, H. A., LEWIS, H. B., HERZMAN, M., MACHOVER, K., MEISSNER, P. B. & WAPNER, S. (1954). Personality through perception. New York: Harper.

WITKIN, H. A., OLTMAN, P. K., RASKIN, E. & KARP, S. (1971). A Manual for the Embedded Figures Test. California: Consulting Psychologists Press.

WOLFF, S. & BARLOW, A. (1979). Schizoid personality in childhood: A comparative study of schizoid, autistic and normal children. Journal of Child Psychology and Psychiatry, 20, 29-46.

WURST, E. (1976). Autismus. Bern: Verlat Hans Huber.

YULE, W. (1978). Research Methodology: What are the "correct controls"? In M. Rutter & E. Schopler (Eds.). Autism: A Reappraisal of Concepts and Treatment. New York and London: Plenum Press.

ZEAMAN, D. & HOUSE,B. J. (1963). The role of attention in retardate discrimination learning. In N. Ellis (Ed.). Handbook of Mental Deficiency. New York: McGraw-Hill.

APPENDIX (1A)
Details of Autistic subjects

1. <u>Average IQ group</u>

Initial	Sex	Age Yr M	PIQ	VIQ	FIQ	Occupation
*]TC	M	16-4	92	91	91	paid work - outside
DH	F	16-6	106	51	76	paid sheltered work
*KH	M	16-11	106	87	96	special workshop
QB	M	19-3	102	87	93	paid sheltered work
EB	M	19-9	108	76	89	paid work - outside
SS	M	18-1	95	81	86	special workshop
NL	M	20-7	87	63	73	special workshop
]TS	M	21-2	86	48	62	special workshop
BE	M	19-6	97	76	84	paid work - outside
~NA	M	18-1	- (88)[a]	-	-	special school

*Questionnaires (ECQ) were not returned for these subjects.
~This subject could only be tested on two subtests of the Performance scale of the WAIS, and also did not participate in experiments (1) and (4).
]These subjects did not participate in experiments (2) and (3).

[a] An estimate of Performance IQ (88) was obtained for subject NA from the Leiter International Performance scale. This was used to classify the subject in the Average IQ group and is incorporated in the calculation of the group mean non-verbal IQ in Table 2.1.

APPENDIX (1B)
Details of Autistic subjects (cont')

2. Lower IQ group

Initial	Sex	Age Yr M	PIQ	VIQ	FIQ	Occupation
EP	M	16-7	81	58	68	special workshop
NK	M	16-0	73	54	61	special workshop
DM	M	17-0	73	60	65	workshop/adult ed.
~SP	M	16-0	69	50	55	special school
DP	M	16-11	64	45	50	special workshop
~NB	M	20-9	73	52	59	workshop/adult ed.
NS	M	24-11	77	73	73	workshop/adult ed.
UL	M	21-7	69	54	58	workshop/adult ed.
~MP	F	19-5	-(57)[a]	-	-	special workshop
*EC	F	16-1	74	66	69	special school

*This subject was not available for experiments (1) and (4)
~These subjects did not pass the criterion test for participation in experiments (2) and (3).

[a] An estimate of PIQ (57) was obtained for subject MP from the Leiter International Performance Scale. This was used to classify the subject in the Lower IQ Autistic group and is incorporated in the calculation of the group mean non-verbal IQ in Table 2.1.

APPENDIX (2)
Details of Older Normal subjects

Initial	Sex	Age Yr M	PIQ
OR	F	17-6	92
KC	M	17-4	106
SL	M	15-8	93
NC	M	15-10	101
NW	M	16-2	108
TT	M	15-6	98
HS	M	16-3	105
TP	F	16-0	98
QW	M	15-8	102
TC	M	15-11	101
EL	M	16-1	95
NB	M	15-9	104
ES	M	15-4	111
DP	M	15-6	91
TP	M	15-9	--*
SM	M	15-4	114
QS	M	15-11	91

* The PIQ for subject TP was not available as this subject had not been tested on all the relevant subtests due to absentism.

APPENDIX (3)
Details of Lower IQ Non-Autistic subjects

Initial	Sex	Age Yr M	PIQ	VIQ	FIQ
QB	M	17-11	68	69	66
PW	M	17-0	74	81	77
HM	M	17-7	81	81	80
QL	M	16-3	74	81	77
HJ	M	17-2	73	88	80
TD	F	17-0	76	73	73
MC	M	16-10	74	74	72
LV	M	21-4	85	76	79
UM	M	21-10	75	66	70
KL	M	20-9	85	70	75
QP	M	20-6	70	60	62
TB	M	16-8	81	-	-

APPENDIX (4)
Details of Younger Normal subjects

Initial	Sex	Age Yr M	PIQ
EB	M	10-10	101
BC	M	10-11	95
BH	M	10-11	111
TM	M	11-2	101
*NR	M	10-9	108
BS	M	11-1	108
MH	F	10-10	112
*TH	M	10-8	109
FP	M	11-5	111
TR	M	10-11	108
EW	M	10-4	98
MT	M	10-9	101
BT	M	11-2	106
DT	M	11-4	114
ND	M	10-10	102
TE	M	10-11	104

*These subjects did not participate in experiments (2) and (3).

Questionnaire about early childhood

For each of the following behaviours, please indicate:

a) whether or not your son/daughter showed the behaviour in his/her pre-school years, i.e. before the age of 5 years
b) at what age(s) did the behaviour start
c) at what age(s) did the behaviour stop
d) how severe the behaviour was using the following scale:
   1. VERY SEVERE - if it occurred at least six times daily
   2. SEVERE - if it occurred between 1 - 6 times daily
   3. QUITE SEVERE- if it occurred less than daily but at least once a week
   4. MILD - if it occurred less than once a week
e) Please give example of specific behaviour wherever possible

1. Was S markedly aloof and indifferent to other people?

   Yes/No.................

   Age started...........

   Age stopped...........

   Severity: very severe /severe /quite severe /mild

2. Did S push people away if they tried to talk or relate to him?

   Yes/No.................

   Age started...........

   Age stopped...........

   Severity: very severe /severe /quite severe /mild

3. Did S seem to be in a world of his own and not aware of people around him?

   Yes/No................

   Age started..........

   Age stopped..........

   Severity: very severe /severe /quite severe /mild

4. Did S go up to people <u>only</u> for physical contact, i.e. touching, cuddling, sitting on lap?

   Yes/No..............

   Age started.........

   Age stopped.........

   Severity: very severe /severe /quite severe /mild

APPENDIX (5)- Cont,

5. Did S go up to anyone, friend or stranger and talk to them and ask repetitive questions?

   Yes/No..............

   Age started.........

   Age stopped.........

   Severity: very severe /severe /quite severe /mild

6. Was S reluctant to initiate communication but responded if others went up to him?

   Yes/No..............

   Age started.........

   Age stopped.........

   Severity: very severe /severe /quite severe /mild

7. Did S prefer to play by himself rather than with other children?

   Yes/No..............

   Age started.........

   Age stopped.........

   Severity: very severe /severe /quite severe /mild

8. Did S avoid eye contact by covering eyes or turning whole body away?

   Yes/No..............

   Age started.........

   Age stopped.........

   Severity: very severe /severe /quite severe /mild

9. Did S seem to avoid eye contact by looking through others?

   Yes/No..............

   Age started.........

   Age stopped.........

   Severity: very severe /severe /quite severe /mild

APPENDIX (5) - Cont,

10. Did S copy words or signs that other people had just spoken or used like a parrot?

    Yes/No..............

    Age started.........

    Age stopped.........

    Severity: very severe /severe /quite severe /mild

11. Did S have words or phrases that he used over and over again e.g. television adverts, phrases used by you?

    Yes/No..............

    Age started.........

    Age stopped.........

    Severity: very severe /severe /quite severe /mild

12. Did S call himself 'you' or 'he'? e.g. did he say 'you want a biscuit' instead of 'I want a biscuit'

    Yes/No..............

    Age started.........

    Age stopped.........

    Severity: very severe /severe /quite severe /mild

13. Did S tend to talk to you about the same things over and over again, e.g. did he revert to the same topic of conversation regardless of context?

    Yes/No..............

    Age started.........

    Age stopped.........

    Severity: very severe /severe /quite severe /mild

14. Did S show any of the behaviours listed below, more than other children of the same age? Please indicate which ones.

    a) jumping with excitement;
    b) unusual movements of hands or arms, e.g. flapping;
    c) spinning;
    d) tip-toe walking;
    e) self-injurious movements such as eye-poking;
    f) other odd bodily movements;

    Yes/No.............

    Age started........

    Age stopped........

    Severity: very severe /severe /quite severe /mild

APPENDIX (5) - Cont

15. Did S show any of the behaviours listed below in a repetitive way? Please indicate which ones.

a) flicking things like pieces of string, sticks
b) tapping 2 objects together
c) rolling pieces of cotton in his fingers
d) pushing toys to and fro without any real pretend play
e) twisting and turning objects in his hands
f) gazing at lights
g) listening to simple sounds
h) feeling surfaces
i) mouthing objects
j) other repetitive use of objects or sensory stimuli
k) any other similar behaviour

Yes/No.............

Age started........

Age stopped........

Severity: very severe /severe /quite severe /mild

16. Did S show any of the behaviours listed below in a repetitive way? Please indicate which one(s)

a) arranging objects in lines/patterns

b) collecting any type of object for no apparent purpose

c) fascination with train time-tables

d) copying extracts from catalogues

e) observing and/or noting car number plates

f) calculations of calendar dates

g) listening to records and cassettes over and over again, perhaps selecting the same short passage each time

h) any other similar behaviour

Yes/No.............

Age started........

Age stopped........

Severity: very severe /severe /quite severe /mild

APPENDIX (5) - Cont

17. Did S have some special routines/rituals which he had invented? e.g. tapping on chair before sitting down, standing up and turning round several times during each meal, intense attachment to one particular toy or object which was carried everywhere.

Yes/No..............

Age started.........

Age stopped.........

Severity: very severe /severe /quite severe /mild

18. Did S show undue distress if there was a change in everyday routines? e.g. sequence of dressing, route taken to familiar places, arrangements of ornaments or furniture.

Yes/No..............

Age started.........

Age stopped.........

Severity: very severe /severe /quite severe /mild

19. Was there anything that S was remarkably good at, i.e. did he show some special skill which was well above his general level of functioning? (Please specify nature of skill)

Yes/No..............

Age started.........

Age stopped.........

20. Did S play pretend games using toys to represent real objects?

Yes/No..............

Age started.........

Age stopped.........

21. Did S play elaborate games with tea-set, toy garage, cars, doll and bed, etc. using them as if real.

Yes/No..............

Age started.........

Age stopped.........

APPENDIX (5) - Cont

22. Did S like 'dressing up' and 'make believe' games with other children when they dress up and pretend to be someone else, e.g. a cowboy, or nurse? (Only rate as yes if there was awareness of the dramatic role so that the child was not just putting on clothes by copying other children)

Yes/No..............

Age started.........

Age stopped.........

23. Did S enjoy the company of other children of similar age?

Yes/No..............

Age started.........

Age stopped.........

24. Did S lift his arms to show eagerness to be lifted up?

Yes/No..............

Age started.........

Age stopped.........

25. Did S greet father/mother on their return to the house?

Yes/No..............

Age started.........

Age stopped.........

26. Did S follow mother around the house imitating her actions and chatting (or pretending to talk)?

Yes/No..............

Age started.........

Age stopped.........

27. Did S go through the stage of babbling, as if talking?

Yes/No..............

Age started.........

Age stopped.........

APPENDIX (6)
Raw Scores on the ECQ

a. <u>Average IQ group</u>

	Subject							
	DH	QB	EB	SS	NL	TS	BE	NA
Section I								
*1.	4	3	3	4	2	3	3	3
2.	0	2	0	2	0	2	0	1
3.	3	3	2	2	0	2	3	2
4.	0	0	0	0	1	2	4	2
5.	0	0	1	0	0	1	3	0
6.	3	2	2	3	2	2	1	0
7.	3	3	2	2	2	3	3	2
8.	0	3	0	0	0	1	0	0
9.	2	3	1	0	2	0	4	0
10.	3	0	3	3	1	2	4	0
11.	3	0	2	3	0	1	3	0
12.	3	0	0	0	2	3	3	0
13.	3	0	3	0	0	3	3	0
14.	3	4	2	4	2	3	1	3
15.	2	2	1	3	1	2	3	0
16.	3	3	3	3	2	1	4	3
17.	0	3	2	0	0	0	0	0
18.	2	2	2	3	3	1	4	0
Section II (p=present; a=absent)								
19.	p	p	p	p	p	a	p	p
20.	a	a	a	a	a	a	a	a
21.	a	a	a	a	a	a	a	a
22.	a	a	a	a	a	a	a	a
23.	a	a	a	a	a	a	a	a
24.	a	a	a	a	a	a	a	a
25.	a	a	a	a	a	a	a	a
26.	a	a	a	a	a	a	a	a
27.	p	p	a	p	p	a	a	a

*These numbers refer to questions on the ECQ as shown in Appendix (5)

APPENDIX (6) - Cont'

b. Lower IQ Autistic group

	Subject									
	EP	NK	DM	SP	DP	NB	NS	UL	MP	EC
Section I										
*1.	2	2	1	2	3	1	2	3	0	2
2.	0	1	0	0	0	0	2	3	0	0
3.	1	1	2	2	3	1	2	2	1	2
4.	0	0	0	0	2	0	0	0	2	0
5.	0	1	0	0	3	0	0	0	0	0
6.	1	0	1	0	0	0	4	0	1	2
7.	2	1	2	2	2	1	4	2	0	2
8.	2	1	0	2	3	0	0	2	0	2
9.	2	1	0	2	0	1	0	0	1	3
10.	0	1	0	0	0	0	1	0	0	0
11.	0	0	1	0	2	0	0	0	0	0
12.	2	2	0	0	2	0	3	0	0	0
13.	0	2	1	0	1	0	0	0	0	0
14.	2	0	3	0	2	0	0	1	2	1
15.	2	0	2	2	3	1	2	1	1	2
16.	2	1	2	0	3	1	2	2	0	0
17.	2	0	0	0	3	3	1	0	0	2
18.	2	2	2	2	2	1	2	3	0	2
Section II	(p=present; a=absent)									
19.	p	p	p	p	p	a	p	p	a	p
20.	a	a	a	a	p	a	a	a	p	a
21.	a	a	a	a	p	a	a	a	p	a
22.	a	a	a	a	p	a	a	a	a	a
23.	p	p	a	a	a	a	a	a	p	p
24.	p	a	a	a	p	a	a	a	p	p
25.	p	p	a	a	p	p	a	a	p	a
26.	a	a	a	p	p	a	a	a	a	a
27.	a	a	a	p	p	p	a	a	p	p

*These numbers refer to questions on the ECQ as shown in Appendix (5).

APPENDIX (7)
The Social Impairment Scale
(modified from the HBS, Wing & Gould 1978)

1. Aloof and Indifferent: either does not interact at all or interacts only to obtain needs or for physical contact;

2. Passive: does not initiate social contact, but responds passively if other people make approaches;

3. Odd: does make social approaches, but these are peculiar, naive or even bizarre. The person does not modify his/her behaviour in the light of the responses, needs or interests of those whom he/she approaches. The interaction is one-sided and dominated by the person being rated.

4. Mostly Aloof, sometimes Passive: stays aloof and indifferent except in a structured one to one situation in which he/she may appear quite amiable and responsive.

5. Sociable but Stilted: does initiate social interaction which is neither odd nor one-sided and repetitive; On the whole, he/she is sociable and communicative. Their social behaviour though, is very stilted and mechanical and appears 'unnatural' in subtle ways.

APPENDIX (8)
IQ Test Results - Average IQ Autistic group

	TC	DH	KH	QB	EB	SS	NL	TS	BE	NA
Test used	C	C	C	A	A	A	A	A	A	A
FIQ	91	76	96	93	89	86	73	62	84	-*
VIQ	91	51	87	87	76	81	63	48	76	-
PIQ	92	106	106	102	108	95	87	86	97	-
INF	11	2	10	5	5	5	4	0	5	-
COMP	4	1	4	4	5	5	2	0	5	-
ARITH	10	5	11	10	3	4	1	1	5	-
SIMIL	10	3	9	9	10	10	9	0	8	-
DIGIT	6	11	11	10	7	7	7	1	7	-
VOCAB	8	1	6	7	5	4	0	0	5	-
CODING	10	9	6	6	6	6	6	4	7	-
P.COMP	5	11	9	9	10	7	7	3	8	-
BLOCK	9	15	13	17	17	13	13	15	15	19
P.ARR	12	9	11	7	13	7	3	0	5	-
OBJECT	9	11	16	13	11	12	12	16	13	15

C = Wecshler Intelligence Scale for Children - Revised
A = Wechsler Adult Intelligence Scales

* This subject (NA) could not understand task requirements for any subtest except Block Design and Object Assembly.

APPENDIX (9)
IQ Test Results: Lower IQ Autistic group

	EP	NK	DM	SP	DP	NB	NS	UL	MP	EC
Test used	C	C	C	C	C	A	A	A	A	C
FIQ	68	61	65	55	50	59	73	58	-*	69
VIQ	58	54	60	50	45	52	73	54	-	66
PIQ	81	73	73	69	64	73	77	69	-	74
INF	5	2	3	3	1	1	8	0	-	6
COMP	1	1	1	0	1	3	5	0	-	5
ARITH	3	5	7	3	1	1	3	3	-	7
SIMIL	6	4	6	3	2	4	9	6	-	1
DIGIT	6	8	7	1	3	2	2	4	-	3
VOCAB	1	1	1	0	1	0	5	0	-	9
CODING	1	1	1	1	1	6	4	4	-	4
P.COMP	9	5	3	5	5	6	7	1	-	4
BLOCK	9	12	15	8	9	10	6	9	10	9
P.ARR	5	3	1	1	1	0	6	4	2	6
OBJECT	12	9	10	11	6	8	10	9	7	8

C = Wechsler Intelligent Scales for Children - Revised
A = Wechsler Adult Intelligence Scales

*This subject was deaf, and could not comprehend test-requirements for all except three tests.

APPENDIX (10)
IQ Test Data: Lower IQ Non-Autistic group

	QB	PW	HM	QL	HJ	TD	MC	LV	UM	KL	QP	TB*
Test	A	A	A	A	A	A	A	A	A	A	A	A
FIQ	66	77	80	77	80	73	72	79	62	70	75	-
VIQ	69	81	81	81	88	73	74	76	60	66	70	-
PIQ	68	74	81	74	73	76	74	85	70	75	85	81
INF	2	6	3	4	11	3	3	7	2	6	5	-
COMP	4	8	5	5	6	5	5	5	4	5	5	-
ARITH	4	5	4	4	6	4	4	4	3	5	4	-
SIMIL	6	7	10	9	9	8	7	8	6	9	7	-
DIGIT	4	4	7	6	4	6	4	6	1	9	2	-
VOCAB	3	5	6	7	6	6	5	5	3	0	6	-
COD	7	7	7	6	6	6	5	7	6	6	6	5
P.COMP	7	7	9	7	7	6	6	7	5	6	10	5
BLOCK	6	5	6	4	4	6	7	10	5	5	8	9
P.ARR	0	5	6	5	6	9	6	7	6	4	6	9
OBJECT	4	5	6	7	5	5	5	8	6	4	9	8

A = Wechsler Adult Intelligence Scale

*This subject had not been tested on the Verbal scale.

APPENDIX (11)
IQ Test Data: Older Normal Group

	OR	KC	SL	NC	NW	TT	HS	TP	QW	TC
Test	A	A	C	C	C	C	C	C	C	C
PIQ	92	106	93	101	108	98	105	98	102	101
COD	10	9	3	12	11	13	14	7	6	11
P.COMP	8	12	9	10	13	8	8	8	12	7
BLOCK	9	12	11	11	14	12	12	12	13	14
P.ARR	7	8	11	10	9	8	11	11	10	8
OBJECT	9	12	12	8	9	8	9	11	11	11

	EL	NB	ES	DP	TP	SM	QS
Test	C	C	C	C	C	C	C
PIQ	95	104	111	91	-*	114	91
COD	10	6	13	8	-	9	6
P.COMP	9	10	12	7	-	14	10
BLOCK	11	13	11	7	10	13	8
P.ARR	9	12	11	11	-	11	11
OBJECT	8	12	11	11	11	13	9

* This subject was not available for some of the tests.

C = Wechsler Intelligence Scale for Children - Revised
A = Wechsler Adult Intelligence Scale

APPENDIX (12)
IQ Test Data - Younger Normal group

	EB	BC	BH	TM	NR	BS	MH	TH
Test	C	C	C	C	C	C	C	C
PIQ	101	95	111	101	108	108	112	109
COD	12	9	12	12	11	11	14	12
P.COMP	13	10	13	8	11	11	13	11
BLOCK	8	12	11	11	11	11	10	13
P.ARR	9	7	11	10	13	12	10	9
OBJECT	9	9	12	10	10	11	12	12

-CONT'

	FP	TR	EW	MT	BT	DT	ND	TE
Test	C	C	C	C	C	C	C	C
PIQ	111	108	98	101	106	114	102	104
COD	12	10	12	10	12	8	13	14
P.COMP	12	11	9	8	12	10	9	9
BLCOK	13	12	9	11	10	14	10	10
P.ARR	9	12	10	11	10	12	11	10
OBJECT	12	11	9	11	11	16	9	10

C = Wechsler Intelligence Scale for Children - Revised

APPENDIX (13)
Individual subject data for Experiment (1)

Total deviation score over 4 trials on each of the 8 conditions

a. Average IQ Autistic group

Condition

	PP	SS	SP	PS	SL	LS	SD	DS
TC	12	6	4	13	13	18	14	9
DM	6	4	4	6	8	8	7	8
KH	7	5	9	6	11	9	7	12
[illegible]B	8	4	6	5	8	8	6	8
SB	7	4	8	8	5	6	9	9
[illegible]	7	5	13	12	10	12	10	9
LL	6	6	13	11	17	13	10	12
TS	5	5	6	12	6	22	8	15
BE	9	4	11	7	7	4	6	6

APPENDIX (13) - Cont'

b. <u>Lower IQ Autistic group</u>

Condition

	PP	SS	SP	PS	SL	LS	SD	DS
CP	6	4	7	5	11	7	7	6
NK	7	6	10	15	15	17	14	16
DM	7	4	8	9	6	7	12	7
[illegible]P	10	6	12	11	15	19	11	10
DF	11	5	9	17	10	18	17	21
PB	13	4	14	7	9	11	13	10
NJ	7	4	11	11	12	14	13	12
U[illegible]	11	7	18	11	10	19	13	19
M[illegible]	13	6	11	10	13	16	16	10

APPENDIX (13) - Cont'

C. Older Normal group

Condition

	PP	SS	SP	PS	SL	LS	SD	DS
OR	8	7	12	7	10	13	15	7
KC	9	4	7	10	10	8	6	6
SL	8	7	7	11	12	12	13	8
NC	10	5	11	7	11	11	11	9
NJ	6	5	8	7	11	9	12	9
TT	5	6	13	8	9	10	6	9
HJ	8	4	5	8	7	7	8	7
TP	8	7	8	10	17	14	21	8
QW	10	6	7	9	13	9	9	8
TC	8	12	10	9	6	11	9	7
TL	7	5	9	6	15	9	10	9
NB	9	6	12	6	11	13	11	9
ES	5	7	11	9	7	6	8	9
DP	8	10	11	12	17	27	14	22
TP	6	10	7	8	13	16	10	14
SM	9	7	9	6	5	8	11	9
QS	10	9	11	11	14	12	8	18

APPENDIX (13) - Cont'

d. Younger Normal group

	Condition							
	PP	SS	SP	PS	SL	LS	SD	DS
CB	8	6	13	13	11	9	15	6
BC	8	5	8	8	9	13	5	8
BH	15	6	19	15	17	20	13	20
CH	13	6	9	11	7	14	9	11
NR	7	5	8	6	8	11	7	10
BS	8	6	6	8	12	13	18	8
MH	9	5	12	8	9	13	14	9
TH	8	7	9	13	15	9	12	10
FP	7	7	12	9	11	15	9	11
TR	13	8	17	9	12	14	12	13
[illegible]	9	7	20	15	12	18	11	16
KT	13	5	8	14	11	8	10	8
BT	8	6	17	10	9	15	12	11
DT	15	6	9	13	5	13	20	9
ND	9	6	11	10	8	13	10	9
TE	7	9	10	11	6	11	13	10

APPENDIX (13) - Cont'

e. <u>Lower IQ Non-Autistic group</u>

Condition

	PP	SS	SP	PS	SL	LS	SD	DS
QB	11	4	12	10	15	8	10	9
PW	8	6	9	9	6	24	7	14
HH	9	5	9	13	16	12	15	9
QL	10	11	9	12	19	14	7	10
HJ	15	8	16	24	12	16	14	15
TD	9	8	18	20	25	22	20	27
HC	9	8	19	26	7	11	13	12
LV	8	6	9	7	8	9	10	13
UH	14	7	17	12	17	16	14	20
KL	16	9	23	20	11	22	13	20
P.	11	5	15	10	13	11	16	10
TB	7	5	10	10	12	9	11	10

APPENDIX (14)
Individual subject data for Experiment (2)

Mean RT (1/100 sec) for each subject for the correct trials for each angle of orientation

a. Average IQ Autistic group

	Angle of orientation (deg)				
	0	45	90	135	180
DH	88	258	347	299	473
LH	192	433	393	523	472
QB	166	290	287	238	386
EB	82	153	95	125	149
SS	105	172	248	213	264
NL	209	252	279	390	341
BH	102	159	190	160	195
NA	204	256	242	241	255

APPENDIX (14) - Cont'

b. <u>Lower IQ Autistic group</u>

	Angle of orientation (deg)				
	0	45	90	135	180
EP	198	273	355	429	469
NK	197	176	309	245	483
DM	161	218	231	238	338
DP	146	294	246	219	271
NS	212	295	322	508	636
UL	251	330	400	334	462
EC	200	240	307	205	361

APPENDIX (14) - Cont'

c. Older Normal group

	Angle of orientation (deg)				
	0	45	90	135	180
OI	141	213	315	181	331
KC	117	162	261	182	262
SL	209	207	297	369	448
NC	108	125	115	136	145
NW	97	165	149	137	170
TT	106	173	197	201	236
MS	79	85	134	115	149
TT	203	174	293	237	323
QW	94	156	194	135	151
TC	124	159	219	202	241
EL	254	161	276	294	458
NB	148	193	327	210	192
BS	126	181	235	210	351
DP	194	253	253	318	278
TP	117	197	224	250	249
SM	93	112	146	155	150
QJ	125	190	167	195	172

APPENDIX (14) - Cont'

d. <u>Younger Normal group</u>

	Angle of orientation (deg)				
	0	45	90	135	180
EB	135	280	428	234	295
BC	178	214	234	288	289
BM	144	287	232	242	347
TM	88	149	185	214	231
BS	204	322	410	258	321
MH	104	213	215	187	184
FP	178	340	399	730	397
TR	79	211	197	314	347
EW	151	229	260	282	300
MT	79	196	229	138	247
PT	184	181	210	196	242
DT	286	277	360	346	296
ND	138	236	319	265	422
TC	208	232	289	287	281

APPENDIX (14) - Cont'

e. Lower IQ Autistic group

	Angle of orientation (deg)				
	0	45	90	135	180
OR	298	381	615	634	796
PW	125	261	372	297	276
HM	204	559	606	942	872
OL	131	305	234	256	307
MJ	515	260	797	435	1445
TD	220	306	393	312	544
MC	298	401	615	610	566
LV	98	166	269	244	368
QP	115	158	184	212	249
UM	196	199	416	299	270
KL	199	283	456	715	671
TB	189	179	190	246	385

APPENDIX (15)

Individual subject data for Experiment (3)

Mean Rt (1/100 sec) for each subject for the correct trials for eachangle of orientation (Alpha-numerics)

a. Average IQ Autistic group

	Angle of orientation (deg)				
	0	45	90	135	180
NL	181	172	154	170	286
DH	79	98	95	126	132
QB	99	127	136	137	196
SS	188	422	183	245	225
BE	73	75	102	73	107
KH	181	177	257	194	362
NA	269	351	320	409	337
EB	80	71	78	92	87

APPENDIX (15) - Cont'

b. Lower IQ Autistic group

	Angle of orientation (deg)				
	0	45	90	135	180
DP	182	234	162	250	194
UL	171	208	194	231	621
EP	180	221	253	322	333
·EC	134	109	165	142	235
NK	141	207	143	231	206
NS	101	140	222	252	—
DM	278	193	183	159	—

*These subjects did not respond correctly on any of the 5 trials for 180 degrees

APPENDIX (15) - Cont'

c. Older Normal group

	Angle of orientation (deg)				
	0	45	90	135	180
OR	75	131	179	126	174
KC	114	120	152	157	206
SL	160	209	397	460	376
NC	108	77	160	114	184
NW	71	84	87	101	133
TT	102	135	165	219	259
HS	77	74	81	90	142
TP	171	112	157	278	340
QW	92	71	84	90	123
TC	93	107	128	111	170
EL	124	106	119	122	288
NB	122	135	188	183	166
ES	126	254	323	242	273
DP	109	152	106	126	182
TP	174	204	338	247	271
SM	140	105	158	109	157
QS	118	116	105	148	170

APPENDIX (15) - Cont'

d. Younger Normal group

	Angle of orientation (deg)				
	0	45	90	135	180
EB	108	101	137	177	168
BC	181	376	331	251	643
BH	151	253	241	257	281
TM	83	134	158	217	259
BS	157	128	181	165	239
MH	84	95	143	127	172
FP	125	196	258	426	399
TR	112	267	176	188	197
EW	196	229	198	296	231
MT	62	78	82	90	177
BT	142	168	182	203	209
DT	250	474	484	530	199
ND	121	215	146	158	151
TE	147	116	138	197	183

APPENDIX (15) - Cont'

e. Lower IQ Non-Autistic group

	Angle of orientation (deg)				
	0	45	90	135	180
OE	155	222	267	269	266
PW	88	90	104	141	167
HJ	134	228	361	323	148
HM	119	222	239	396	918
TD	130	181	177	212	330
QL	117	127	119	179	206
MC	203	262	265	401	263
LV	96	194	150	168	300
QP	140	136	155	207	278
UM	179	204	209	161	185
KL	153	274	288	615	452
TB	91	98	173	145	438

APPENDIX (16)
Individual subject data for Experiment (4)

Total time taken (sec) for each set of designs

a. Average IQ Autistic group

	SET*							
	1	2	3	4	5	6	7	8
TC	334	191	67	54	81	63	64	54
DH	96	51	33	36	40	39	34	30
PH	47	26	38	24	35	28	39	23
OB	38	56	29	22	32	24	26	25
EB	45	35	41	30	47	39	32	25
SS	92	71	57	72	57	73	50	56
NL	104	67	54	42	47	41	34	45
TS	88	41	31	40	42	36	30	31
BE	113	69	36	36	41	34	32	36

*KEY FOR SETS 1 - 8

1. Whole Oblique Rotated designs
2. Whole Oblique Unrotated designs
3. Whole Vertical Rotated designs
4. Whole Vertical Unrotated designs
5. Segmented Oblique Rotated designs
6. Segmented Oblique Unrotated designs
7. Segmented Vertical Rotated designs
8. Segmented Vertical Unrotated designs

APPENDIX (16) - Cont'

b. Lower IQ Autistic group

SET

	1	2	3	4	5	6	7	8
EP	104	70	82	67	96	63	72	62
NK	112	240	62	53	62	59	61	53
DM	148	61	36	38	44	36	37	30
SP	116	86	54	54	69	77	54	43
DP	182	141	87	109	78	51	65	48
NB	58	42	40	40	29	33	30	23
NS	295	133	81	116	90	84	80	66
UL	286	87	109	55	70	71	45	43
MP	92	101	35	35	32	43	28	33

APPENDIX (16) - Cont'

c. <u>Older Normal group</u>

	SET 1	2	3	4	5	6	7	8
OR	90	62	65	66	42	30	40	22
KC	78	51	58	50	54	62	57	75
SL	72	65	51	57	59	45	58	50
NC	78	86	48	76	44	34	30	24
NW	61	46	43	39	30	30	25	24
TT	72	75	49	29	57	32	43	38
HS	74	54	36	34	33	40	24	30
TJ	147	79	93	46	46	39	50	30
OW	59	80	38	38	44	39	34	36
TC	59	66	34	38	33	31	31	29
EL	73	72	54	56	49	38	47	33
MB	65	57	43	40	33	31	25	31
IS	65	51	45	41	28	30	42	25
DP	267	167	84	115	84	47	40	36
TP	86	46	49	39	44	35	39	28
SM	129	56	42	34	44	31	30	31
QJ	256	221	65	69	68	40	51	29

APPENDIX (16) - Cont'

d. Younger Normal group

	SET							
	1	2	3	4	5	6	7	8
EB	200	325	84	79	51	41	30	26
BC	264	165	104	82	91	41	72	39
BH	206	184	91	103	88	51	52	40
TM	111	69	63	81	71	32	44	33
NR	222	124	93	98	72	57	66	43
PS	297	279	87	106	62	47	39	36
MH	151	195	70	76	64	86	45	29
TH	71	100	77	49	61	49	41	36
FP	110	57	66	49	47	52	45	36
TR	505	99	57	41	53	47	51	34
FW	268	118	84	220	82	56	81	43
MT	224	124	71	84	70	38	51	25
BT	172	115	150	65	72	64	63	44
DT	268	136	53	94	66	49	59	36
ND	253	142	90	72	81	76	57	43
TE	182	247	51	48	41	30	28	26

APPENDIX (16) - Cont'

e. <u>Lower IQ Non-Autistic group</u>

	SET							
	1	2	3	4	5	6	7	8
OD	366	335	98	249	104	63	50	50
PM	133	410	56	203	61	35	36	34
HM	482	316	127	337	67	84	76	56
OL	620	810	118	303	107	75	47	41
HJ	900	630	900	747	179	141	91	66
TD	900	554	296	89	339	47	76	38
MC	53	71	234	96	302	647	336	476
LV	142	131	90	56	91	52	58	56
UM	746	423	117	105	224	46	58	29
PL	579	391	108	88	200	141	120	67
OP	72	91	182	82	64	43	59	40
TE	114	109	57	65	87	44	40	38